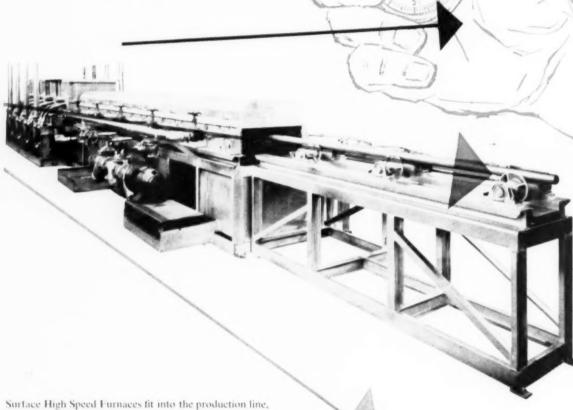
eta



stress relieving at 120 feet/minute

20-foot welded steel tubes travel through this Surface Combustion High Speed Furnace with stop-watch precision at the speed of 120 feet per minute, fast enough for any production line. Such speed requires high heat input (the tubes heat to 650 F. in 6 seconds) which, in turn, demands split-second control of the "time exposure" in the heating chamber. This presents the kind of heat engineering and materials handling problems with which Surface has had such long and productive experience.



Surface High Speed Furnaces fit into the production line, eliminate heat treat bottlenecks. They are designed in many sizes for a wide range of processes on ferrous and non-ferrous metals. They can be automatic or semi-automatic, gas or oil fired. Write for Literature Group H53-5 and see how these "hot-rod" furnaces can give you savings in heating time, equipment cost, fuel, maintenance, floor space, metal, and labor.



SURFACE COMBUSTION CORPORATION . TOLEDO 1. OHIO

ALSO MAKERS OF

Kathabar HUMIDITY CONDITIONING Janitrol AUTOMATIC SPACE HEATING

IN THIS ISSUE



The alchemist on the front cover searching for the "Philosopher's Stone" has his modern counterpart in the engineer searching for the ideal high-temperature material (see page 96). Cover design is by Ralph Haase, student at Cleveland Institute of Art.

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When you been this the big Metal Show & Congress will be events in the past, but as I write this it's still two weeks before the doors fly open, and that fact leaves me high and dry as far as actual reporting is concerned. But I just feel like predicting a thing or two about these events, and then when M.P. comes out the first week in November I'll read this column again and see how close I have come. So here goes with a crystal-gazing report on the 35th National Metal Congress and Exposition:

It was the largest convention in the history of A.S.M. More members attended than ever before,

The 211 papers all about metals were well delivered and well received.

The A.S.M. Seminar was again at the top with Prof. Alan Cottrell, the A.S.M. visiting lecturer from England, shining in the spotlight.

Don Clark of Cal. Tech. gave the Campbell Memorial Lecture in true California style.

Free coffee period—another A.S.M. service for the members was relaxing and relieving.

The banquet was a sellout, the medalists were acclaimed, the speaker dynamic, the food excellent.

About 75 ladies enjoyed the luncheons, trips, theater and card party. The highlight was the luncheon-canasta party at A.S.M.'s National Headquarters (one of Cleveland's finest old Euclid Avenue mansions).

And how they rolled into the educational lectures and appreciated the fine work of the speakers—and the four o'clock coffee break just fitted into the close schedule.

The Metal Show "Dorm" at the Auditorium was an ace in the hole and the 100 members and guests who made use of it had clean sheets and a good sleep and, what's more, it didn't cost 'em a ... cent.

Young Engineers' Day on Friday was a humdinger—some 1500 faculty and students came from engineering schools within 150 miles of Cleveland. Special trains from Columbus and Pittsburgh with buses from the other spots poured these eager-beaver engineers into the Exposition. It gave them an insight into the metals field such as they could secure in no other way. Since 50% of all engineering graduates find their life's work in the metal industry, the "Engineering Society of the Metals Industry" feels a responsibility to acquaint young engineers with prospects in the metals line. Consequently, the A.S.M. gladly picked up the tab for the complimentary luncheon and transportation costs of these coming young engineers.

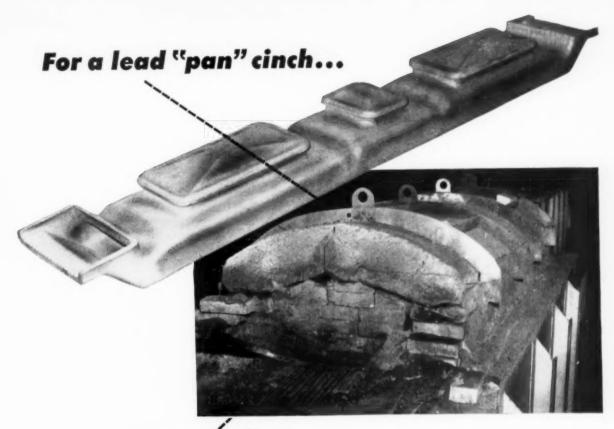
I could go on indefinitely pulling this and that out of my thoughts—events that have not yet happened. I can only make these bold forecasts because I know the careful and conscientious attention to plans and details that the fine staff here at A.S.M. has given during the past year. This one fact is known to all of us—if the plans and details are not worked out and firmed by the opening day of the Convention—then it's too late.

Too late? May it never happen to you or to us.

Cordially yours.

Bill

W. H. EISENMAN, Secretary American Society for Metals



it's THERMALLOY to outlast cast iron by 479 days!

A large steel and wire company uses a double-lead patenting furnace to give good drawing qualities to wire. In this process, wire is drawn through a "lead" pan enclosed in the furnace where temperatures range from 1600 to 1650°F.

Previously, cast iron "lead" pans were used . . . and the furnace had to shut down nearly every 21 days because the pan burned out and needed replacement. Then, a Thermalloy "lead" pan with integrally cast sinkers was installed. To date, this pan has over 500 days of service . . . saving this company expensive hours of repair and down time.

This is just one example of how a Thermalloy heat-resistant casting has helped a manufacturer to realize more economy in heat-treating parts. Do you have a similar need for Thermalloy in retorts, furnace parts, trays, racks, pots or muffles? Call in an Electro-Alloys engineer for full information, or write Electro-Alloys Division, 4002 Taylor Street, Elyria, Ohio.

- THERMALLOY "LEAD" PAN ADVANTAGES -

- · Resists air-line attack, scaling and oxidation.
- · Higher strength prevents sagging and distortion.
- Less weight means easier installation and less maintenance of supporting arches.
- Greater resistance to abrasion.

*Reg. U. S. Par. Off.



ELECTRO-ALLOYS DIVISION

"LIGHT WEIGHT PLATE and SHEET"

now means only one metal:

MAGNESIUM

B&P's rolling mill, now in its second year of operation, provides an efficient source of Magnesium plate and sheet F.O.B. Detroit.

This mill rolls Magnesium only, it is now reducing costs for B&P's fabrication-and-assembly customers, and is also supplying the growing demand for flexible, low-cost production of Magnesium plate and sheet in commercial grades—also a limited range of specification grades.



WHAT DOES THIS B&P ROLLING MILL PRODUCE?
Ask us to send Folder No. 1.
MAGNESIUM IS EASY TO WELD . . . HOW?
Ask us to send folder No. 2.



Engineering and Design



Rolling Ingot into Sheet and Plate



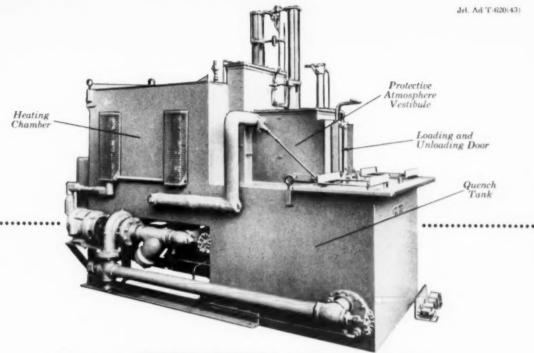
Fabrication and Assemblies



BROOKS and PERKINS Incorporated

1958 W. FORT ST. . DETROIT 16, MICH.

LIGHTNESS . . . PLUS!



A new HOMOCARB' furnace with

protected quench

Now, for the first time, work can be directquenched from a Homocarb furnace under a protective atmosphere.

This new horizontal Homocarb combines the well known benefits of the Homocarb method . . . continuous, automatic control of time, temperature and atmosphere . . . with a protected quench. Work moves directly from the furnace to the quench under a protective atmosphere . . . without exposure to air.

Heat treaters, metallurgists and production men will quickly recognize that this new L&N Homocarb furnace—complete with Microcarb* atmosphere control—marks a significant step forward.

The complete equipment consists of:

- The new horizontal Homocarb furnace with protected quench
- 2. Microcarb atmosphere control
- 3. D.A.T. three-function temperature control

For complete information just write us at 4927 Stenton Avenue, Phila. 44, Penna.













At the IBM plant in Poughkeepsie, N.Y. they refer to their protected quench Homocarb as a "problem-solyer". For example, the brackets shown ½ size, formerly made of 1065 steel to meet physical requirements, presented severe forming problems. Now IBM forms these

parts of 1010 steel. They are then carburized in the Homocarb furnace at 1700 F to a surface carbon content of 0.65% and direct-quenched under protective atmosphere. Physical specifications are well within specified tolerances, and cost of forming has been sharply reduced.

Metal Progress is copyrighted, 1953, by American Society for Metals and is published at 404 N. Wesley Ave., Mt. Morris, Ill. Issued monthly;

subscriptions 87.50 a year. Entered as second-class matter Oct. 21, 1953, at the post office at Mount Morris, Illinois, under the Act of March 3, 1879.

PHOTOMICROGRAPH OF ORDINARY SAE 52100

lt's Cleaner

PHOTOMICROGRAPH OF FERROVAC 52100

It's FERROVAC 52100

And its Fatigue Life is up to 100 Times Longer, as shown by recent tests at National Research Corporation. Vacuum-melting removes practically all gases and oxide inclusions from Ferrovac 52100.

It's cleaner. It's purer. These same characteristics in other vacuumcast metals improve physical, chemical and electrical properties.

Technical data sheet showing performance of Ferrovac 52100 now available. We can now ship from stock rods of 52100 in the following diameters — 15/16", 11₈", 5₈". On order we will supply test samples or commercial quantities of vacuum-cast alloys to customer's specifications. Write for more information.

VACUUM-MELTED METALS AVAILABLE FROM VMC:

Cuprovac-E% (Electronicgrade Copper)

Nivac P* (Passive Nickel) Nivac Series (Nickel and Alloys)

Ferrovac - 52100 ®

Ferrovac - 4340 ®

Other metals or alloys vacuum-cast to customer specifications.

HIGH PURITY METALS HIGH VACUUM CASTING SPECIAL ALLOYS GF (Gos Free) METALS



VACUUM METALS CORPORATION

Subsidiary of National Research Corporation
70 MEMORIAL DRIVE, CAMBRIDGE 42, MASSACHUSETTS

WHAT'S YOUR PROBLEM

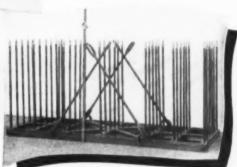
WELDCO SPECIALISTS HAVE THE ANSWER!

In HUNDREDS of plants, you'll find Weldco equipment all along the pickling line. For Weldco products are made of corrosion-resisting, hot rolled metals, which withstand attack from hot acids and other pickling solutions. They are strong yet lightweight, wear-resistant, durable, and long-lasting. You get all these advantages when you specify Weldco hooks, mechanical picklers, crates, baskets, racks, chain, steam jets, and accessories.

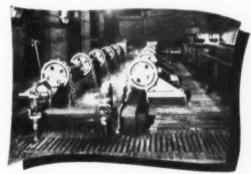
Weldco offers a complete, well-designed line of pickling equipment . . . plus the services of our experienced staff. Let Weldco engineers take care of all your pickling needs. For any problem, large or small, they have the practical, cost-cutting answer.



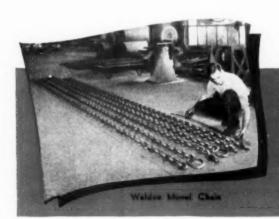
Weldco Pickling Hooks



Weldco Sheet Pickling Crate



Weldco Mechanical Bar Pickler



Weldco Mechanical Coil Pickler



THE YOUNGSTOWN WELDING & ENGINEERING COMPANY

3720 DAKWOOD AVE. . YOUNGSTOWN 9, DHIO



In its Peoria, Ill., plant, Caterpillar Tractor Co. uses power spray washers to remove cutting oils and rust preventives from steel and cast iron parts . . . prior to assembly or further processing. In past years, the Company has tried several types of cleaners in an effort to make the spray wash operation as economical and efficient as possible.

Some months ago a Pennsalt service man suggested a trial of a Pennsalt Cleaner. The results of the test were highly satisfactory: the Pennsalt Cleaner maintained Caterpillar's standards of quality and efficiency while proving considerably more economical. This Cleaner is now used in 71 power spray washers.

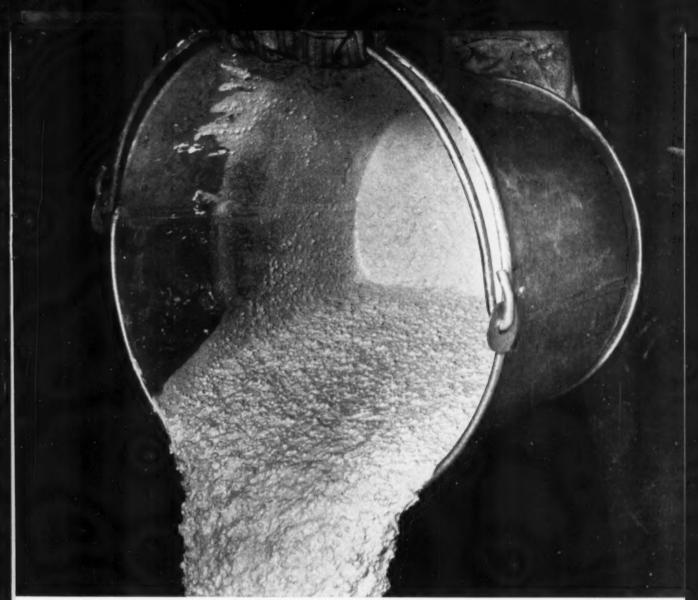
Many another plant has come to the same conclusions about Pennsalt Cleaners. They have powerful detergent effect and long working life.

The feature that makes Pennsalt Cleaners all the more remarkable—and desirable—is their economy. While outperforming competitive cleaners, they almost always prove to be considerably cheaper to use.

An experienced Pennsalt service man in your area will be glad to tell you more about the many specialized cleaning products in the complete Pennsalt line. For the name of the Pennsalt man nearest you, or for further information, write: Metal Processing Department, Pennsylvania Salt Mfg. Co., 442 Widener Bldg., Philadelphia 7, Pa.







Millions of tiny alumina "bubbles help block heat loss through this . . .

New Castable Cement-Good to 3100 F

Here's a castable cement that is also one of the most refractory materials available. Consisting of pure alumina bubbles and highest grade calcium aluminate, it is inherently inert, chemically stable, and will withstand temperatures up to at least 3100 F with practically no shrinkage. It is unaffected by furnace atmospheres and combustion gases. The hollow spheres of alumina make the cement one of the best insulating refractories for really high temperature work. It also follows that it is light in weight, and has low heat capacity.

These ALFRAX® BI aluminum oxide cements (there are actually three types) are particularly easy to install. You just mix with water and pour—like Portland cement. Linings can be put in with a minimum of labor and down time. And, once in, they stay in, even under conditions that quickly destroy other refractories.

For example, one manufacturer lines high temperature ducts (that are sometimes run at over 3000 F) with 3"-thick MULLFRAX® electric-furnace mullite shapes, and backs these

up with 8" of ALFRAX BI cement. Cement shrinkage is practically nil, even at these temperatures. The cement stays free of cracks, and makes a durable monolithic lining that prevents seepage of high-pressure gases.

You have to experience comparative results to believe them. For full data on these castable cements and on other super refractories by CARBORUNDUM, use this handy coupon.

CARBORUNDUM

Registered Trade Mark

Dept. C-113, Refractories Division The Carborundum Company Perth Amboy, N. J.

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A Report from Vanadium Corporation

How Vanadium Corporation's long-range expansion program is helping industry.

CHROMIUM ALLOYS

Vanadium Corporation's new plant at Graham, West Virginia, has been especially equipped to produce—by a unique new process—a remarkably clean, dense new <u>low carbon ferrochromium</u>. This new alloy combines a normal silicon content with a high chromium-to-carbon ratio which enables the steelmaker to produce stainless steels of extremely low carbon content without resorting to modification of furnace and melting practices.

The new Graham plant also produces various alloys of <u>ferrochrome-silicon</u>. Additional modern facilities at Niagara Falls are producing increased quantities of <u>high-carbon ferrochromium</u> by Vanadium's exclusive process. There is an ever growing demand for these clean, high-density Vancoram Alloys—particularly in the many applications where quality and economy are primary considerations.

GRAINAL ALLOYS

These are the multiple-element alloys developed by Vanadium Corporation that are now being used to produce annually over a million tons of boron steels. Replacing critical and more costly elements with respect to hardenability and other properties, Grainal Alloys have proved invaluable not only in times of heavy defense production but also in providing low-cost, high-quality alloy steels for our peacetime economy.

New use for Grainal Alloys: alleviating the problem of hot shortness in stainless steels. Field reports indicate that small additions of Grainal improve the hot working characteristics of stainless, thus cutting conditioning costs and increasing output.

Anticipating the future demand for Grainal Alloys, Vanadium Corporation has included at its new plant at Cambridge, Ohio, additional facilities for their production.

VANADIUM ALLOYS

With government restrictions on the use of vanadium now lifted, steelmakers can once again take full advantage of Vancoram ferrovanadium. Small additions of this versatile, economical alloy often do the work of large amounts of other, more expensive alloys—a little goes a long way.

Vanadium Corporation has played an important role in helping to make vanadium again available in large commercial quantities.

For example . . .

New VCA mines in Colorado have substantially increased the production of *ranadium ore* in conjunction with western uranium operations.

Complete new facilities at the Cambridge, Ohio, plant will soon be in full operation to further insure a plentiful supply of highest quality ferrovanadium for every application—from watch springs to giant forgings.

More news about Vancoram Ferrovanadium: Available for many years both in bags and drums, ferrovanadium can now be furnished palletized for greater shipping economy and ease of handling.

SILICON METAL AND ALLOYS

Among the promising new nonmetallic materials developed during World War II are the Silicone plastics. Their outstanding properties include resistance to both high and low temperatures thanks to silicon metal used in their manufacture.

Vanadium Corporation's new Graham plant provides the plastics industry with a dependable new source of silicon metal of highest quality.

The new Graham plant is also furnishing a complete range of silicon metal and *ferrosilicon* to the aluminum, iron, steel, magnesium and other industries.

RESEARCH

Now nearing completion at the Cambridge plant is the new enlarged Research Center. This new center contains extensive, modern facilities for the further development of all Vancoram products—which also include, titanium alloys, master aluminum alloys, and a complete range of foundry alloys for every application.

Vanadium Corporation of America

420 Lexington Avenue, New York 17, N. Y.

Producers of alloys



metals and chemicals



PITTSBURGH • CHICAGO • DETROIT • CLEVELAND
PLANTS: Niagara Falls, N. Y., Graham, W. Va.
Cambridge, Ohio

Something NEW in Selective Heat Treating . . .

LIQUID FLAME HEATING

This radically new but commercially proven application of the world renowned Ajax Salt Bath Furnace offers industry many unique advantages over any other method for selectively heating the rim or edges of circular objects, hardening teeth on gears or sprockets, and any other products that require peripheral heating.

The technique of operation is simplicity itself: Either a neutral type salt bath or a carburizing bath, heated by the internal electrode system, is maintained automatically at the required specific temperature. A number of the parts, such as gears, to be selectively heated can be mounted on a shaft within a suitable fixture which is placed over the salt bath. Only that portion of the periphery to be heated (such as the teeth) is immersed in the bath. The work is then rotated and heating is extremely rapid due to conduction by the intimate contact with the liquid salt.

Teeth of four 12" dia. gears, SAE 4140 steel, weighing 36 lb. each, being liquid flame hardened. Conventional carburizing bath operated at 1550 F. Total time cycle 4 minutes, followed by all quench. Resultant tooth hardness 52 RC with tough core of only 36 RC.

COMPARE THESE ADVANTAGES . . .

with their periods from our flow

I FAST AND UNIFORM HEATING

Speed of heating approximates the retail which the work conducts heat. The hat "curry-over" layer of our clinging to heated portion supplements heating account collection.

2 NO OVERHEATING

Since no temperature "head" is employed, everheating of the work is impossible.

3 NO OXIDATION, SCALING, ON DECARBURIZATION

The surface of work heated is prorected from oir throughout entire operation due to the layer of liquid soft clinging to the revolving surface.

A PLENIER LTY

When not used for "Liquid Flome feeting", the sell both is everlable or conventional best trading uses.

LESS COSTLY

Enter operation, both as to temperature and liming, is automatic using analytical labor. Large balches of work can be treated simultaneously, effecting important economies over a place by view against a.

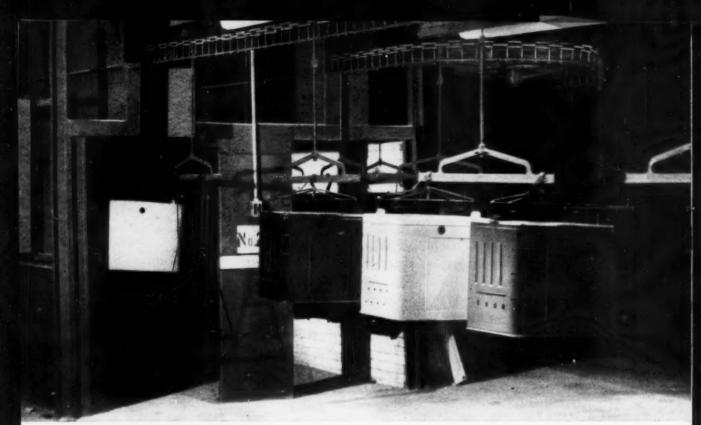
HERE'S PROOF

Let us treat sample batches of your work without obligation in the Ajax Metallurgical Service Laboratory. Better still, come see it done yourself! Reprint No. 73 sent on request.

Associate companies: Ajax Electric Furnace Corp. • Ajax Engineering Corp. • Ajax Electrothermic Corp.

OVER 4,000 INSTALLATIONS . . . more than all other salt baths combined

AJAX ELECTRIC CO., INC., 910 Frankford Ave., PHILADELPHIA 23, PA.



ELECTRIC RANGES at General Electric's Appliance Park in Louisville, Kentucky, move through furnace for firing of porce-

lain-enamel finish, G-E pyrometers (Type HP-3) provide the close temperature control required to properly harden the finish.

QUALITY CONTROL THROUGH CLOSE TEMPERATURE CONTROL . . .

G-E Pyrometers Help Sustain Quality

Known the world over for its fine electric kitchen ranges, General Electric's Appliance Park in Louisville, Kentucky is now using one hundred HP-3 pyrometers in its manufacture of ranges. These instruments control the critical furnace temperatures required for proper firing of the porcelain-enameling on range shells.

Precise and complete temperature control is essential to the quality control of any product undergoing heat processing. The proven close control afforded by G-E HP-3 pyrometers can help you to keep rejects at a low level, while maintaining product quality at the peak demanded in return for customer satisfaction.

Precision control—at low cost—is inherent in the HP-3 pyrometer features which follow:

PRECISION CONTROL

G-E pyrometers will read the same everytime temperature conditions are the same. That's repeatability—the essence of precision control. A repeatable process means you get identical results, assuring uniform high quality.

Low-cost precision control begins with G.E.'s low pyrometer prices, starting at \$215.78.*

HIGH SENSITIVITY

Any change in furnace temperature equivalent to 2/10 of 1% of full scale is enough to initiate control action. Effective sealing of all removable parts helps keep dirt and moisture from offsetting this sensitive control.

SUSTAINED HIGH ACCURACY

Accurate indication and control is provided by: (1) cali-

GENERAL ELECTRIC



TWENTY-ONE G-E PYROMETERS insure proper distribution of temperature throughout the eighty-eight-foot zone of each

furnace. This precise and extensive temperature control is a major factor in assuring a high-quality porcelain-enamel finish.

of Porcelain Finish on Electric Ranges

brated accuracy of % of 1% of full scale; (2) automatic cold-junction compensation, which adjusts for changes in ambient; and (3) high stability during changes in voltage, frequency, or humidity.

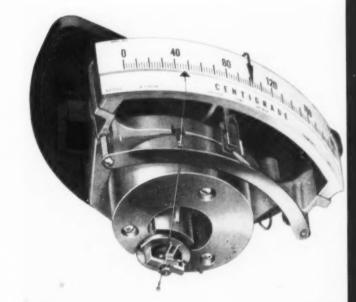
SEVERAL TYPES AVAILABLE

HP-3 pyrometers are available as indicators, indicator controllers, and protectors in either 2-position or 3-position modèls. Scale requirements can be fulfilled from a variety of ranges in the 0-3000 F span.

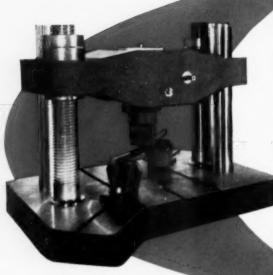
MORE INFORMATION

For complete information on how G-E pyrometer equipment can help you to improve or maintain product quality, contact your G-E Apparatus Sales representative, or write for Bulletin GEC-713 to General Electric Company, Section 602-263. Schenectady 5, N. Y.

*Manufacturers suggested retail price.



SHOCK-RESISTANT CONSTRUCTION of the General Electric HP-3 pyrometer sustains accuracy with sturdy stationary parts, 3 1/4-lb, alnico magnet, and a lightweight moving element.



How Physical Testing HELPS METALS ENGINEERS

Typical set-up for testing bending stress in bar stock.

You won't waste money processing substandard materials if you use physical testing at several stages of production.

Incoming Materials — You can quickly and easily check the quality and uniformity of incoming raw material and parts. Materials not up to your standards can be rejected before flaws show up in machining or assembly.

Sub-Assemblies — By regularly testing sub-assemblies, you can check the quality of welds, riveted joints or other operations. Faulty operations can be remedied before a large number of substandard parts are produced.

Finished Products — Sample testing of finished products will assure that your products meet your company standards. Customer complaints will be reduced and returned products minimized.

You can test practically anything with a Richle Universal Testing Machine. Because it has five standard

scale ranges, the Riehle Pendomatic Universal Testing Machine is the equivalent of five testing machines in one. You merely turn the selector knob to the proper range and conduct your test. Accessories and special tools are available for special tests.

Riehle Universal Testing Machines are built with hydraulic or screw power loading units. Each type is available in a variety of sizes with capacities up through 400,000 lbs.

Write for illustrated catalog containing specifications and accessories to Dept. MP-1153.



Riehle Universal Testing Machine checking tensile strength of a finished part.

RIEHLE TESTING MACHINES

Division of American Machine and Metals, Inc.
EAST MOLINE, ILLINOIS

"ONE TEST IS WORTH A THOUSAND EXPERT OPINIONS"

engineering digest OF NEW PRODUCTS

Shell Molding Machine

A new model shell molding machine, incorporating new features designed to increase output and uniformity of molds, has been announced by Shalco Engineering Corp. According to the manufacturer, the unit was specifically designed to make precision shell molding practical for all foundries. Reported to produce up to two shells per



minute, this gas or electric unit is available with automatic timers for both inversion and curing cycles. Positive alignment for precise shell duplication is claimed. A new dump box design increases uniformity and compactness of shells. Castings with tolerances as close as 0.005 in, per in, are claimed to be obtainable from Shalco shell molds.

For further information circle No. 1365 on literature request card on p. 32-B.

Dew Point Controller

An automatic dew point controller which regulates dew point in controlled atmosphere furnaces has been developed by Ipsen Industries, Inc. The new self-contained electronic unit, continuously records and controls furnace dew point for automatic carburizing and carbon restoration. Dew point settings are made by simply turning an indicator. As there is a definite relationship between the dew point of the atmosphere and its carbon potential, automatic control of the furnace dew point will assure bright, scale-free results in a wide variety of heat treating operations, including carburizing, carbonitriding, carbon restoration, annealing, normalizing and hardening. The electron'c element is replaceable.

For further information circle No. 1366 on literature request eard on p. 32-B.

Heavy Duty Etcher

A newly designed electric etcher has been announced by the Martindale Electric Co. Its range of six heats makes it suitable for various sizes of parts. It may be left connected to the line without danger of overheating when not in use.

For further information circle No. 1367 on literature request card on p. 32-B.

Thread Inserts

Heli-Coil Corp. has announced the availability of 47 standard sizes of stainless steel wire thread inserts, five in the automotive spark plug series, 17 in the national and unified coarse thread series, six in the national pipe thread series, 15 in the national and



unified fine thread series, and four in the aviation spark plug series. In-

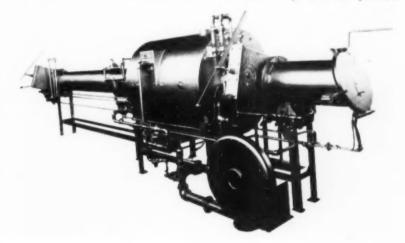
Furnace For Treating Stainless Steel

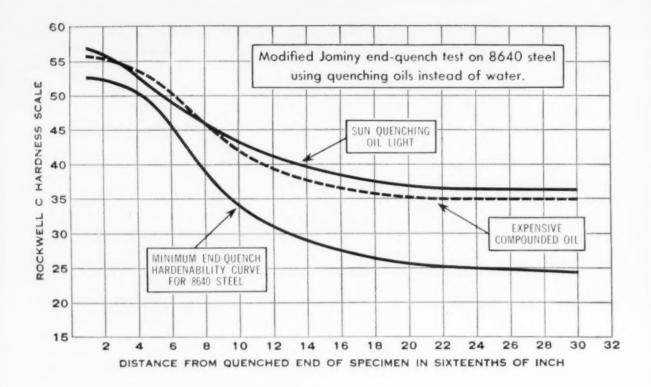
A new furnace has been built and field tested by Lindberg Engineering Co. for bright hardening and bright annealing of stainless steels and other high alloys, with no oxidation or discoloration. It can also be used for copper brazing of stainless steels. The atmosphere is controlled so that it is not contaminated by oxygen or water vapor. A full muffle prevents contaminations of the atmosphere from the combustion products.

Automatic purging chambers are

located at both the charging and discharging ends. Parts are cooled rapidly in a water-jacketed chamber under the protection of the atmosphere, with water temperature automatically controlled. In the larger models, as many as four baskets of work can be in the cooling chamber at one time. Work is transferred manually from chamber to chamber by means of a pusher rod inserted into a hole in the charging door. The protective atmosphere consists of dissociated ammonia or pure dry hydrogen.

For further information circle No. 1368 on literature request card on p. 32-B.





You can do 95% of all quenching jobs by using SUN QUENCHING OILS

This has been proved again and again in industrial heat treating departments and in the laboratory. The above test curves compare the results obtained from Sun Quenching Oil Light and those from an expensive compounded quenching oil. The hardnesses obtained are far above the commonly accepted minimum.

In addition to assuring consistently uniform physical characteristics, Sun Quenching Oils prevent sludge formation and help remove any deposits that may exist. Oil coolers are kept clean; maintenance costs are decreased. Sun Quenching Oils lower operating costs too. They thin out when heated, drain off parts faster and more completely. Make-up is materially reduced.

For more information about Sun Quenching Oils and how they can help you, call your nearest Sun office or write Sun OIL COMPANY, Philadelphia 3, Pa., Dept. MP-11.

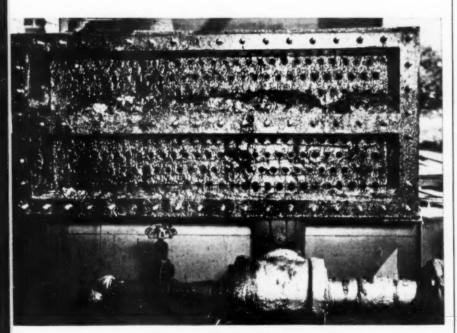
SUN OIL COMPANY



PHILADELPHIA 3, PA. + SUN OIL COMPANY LTD., TORONTO & MONTREAL



THIS PLANT QUENCHES ALL TYPES and sizes of automotive and aircraft forgings. Sun Quenching Oil Light serves all five of the 2400-3000 gallon systems. In the seven years the shop has been using this oil, no unit has been down except for normal mill scale removal.



AN OIL THAT FORMS SLUDGE CLOGS oil coolers, increases maintenance and operating costs. Sun Quenching Oils have a natural detergency which helps keep the systems clean and removes any deposits that may exist.

INDUSTRIAL PRODUCTS DEPARTMENT
SUN OIL COMPANY



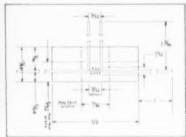
PHILADELPHIA 3, PA. . SUN OIL COMPANY LTD., TORONTO & MONTREAL

serts for the national and unified thread series are supplied in 1, 1½, 2, 2½ and 3-diameter lengths.

For further information circle No. 1369 on literature request card on p. 32-B.

Smallest Strain Gage

The smallest SR-4 bonded resistance wire strain gage yet developed has been announced by the Baldwin-Lima-Hamilton Corp. The new strain gage has a gage length of only 1/32 in., half of the previously smallest gage.



It is Bakelite-base gage of the wraparound type, with cupro-nickel wire, and is applied by phenol-resin cement. Nominal resistance is 120 ohms and the average gage factor is 1.4, guaranteed within 10%.

For further information circle No. 1370 on literature request card on p. 32-B.

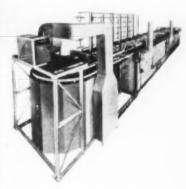
Impregnating Castings

A recently developed impregnator that stops leakage of gases in metal castings has been announced by Nelsonite Chemical Products, Inc. The new formula has worked well with aluminum and iron castings. Castings are merely immersed without use of pressure or vacuum equipment. At least three days are required for curing.

For further information circle No. 1371 on literature request card on p. 32-B.

Automatic Plating Machine

Wagner Brothers' new fully automatic electroplating machine holds interest not only for those concerned





Can you afford the high cost of outmoded metal cleaning equipment? The new, modern Circo vapor degreasers-whether large or smallare engineered to save you 30% in solvent consumption and up to 50% in labor costs through more efficient design and operation. Circo, drawing on a background of 30 years experi-

ence in vapor degreasing, builds into its equipment such solvent-saving features as balanced condensing coils, leak-proof pumps, dual vapor-level control and regulated heat input. Circo degreasers are built to perform faster, save precious man-hours, through such construction features as easy access and clearance on two sides, large clean out doors, and wellplaced controls and switches.

And ONLY Circo-engineered designs can provide these additional advantages:

- Immediate interchangeable operation, Trichlorethylene or Perchlorethylene
- 2. 208 standard designs to choose from
- 3. Automatic reclaiming of solvent
- Lowered maintenance costs ease of cleaning and servicing
- 5. Complete technical field service custom-engineered installations

Profit from Circo's firm policy of constant research and study that adapts the latest and best in metal cleaning to YOUR requirements.

And now - Circo Pioneers In Ultrasonic Cleaning

Circo again leads the way with the most modern and talked about metal cleaning development of the century. The new Circosonic Degreaser, equipped with General Electric ultrasonic generator, cleans metal parts by the power of sound faster than ever thought possible and to a degree of cleanliness that passes the most stringent industrial standards. The Circosonic degreaser may fit your operating needs.

Write for full technical literature.

CIRCO HAS DEVELOPED A COMPREHENSIVE, AUTHORITATIVE MANUAL ON THE SUBJECT OF VAPOR DEGREASING. WRITE TODAY, FOR THIS 32-PAGE BOOKLET. NO OBLIGATION, OF COURSE.



EQUIPMENT COMPANY

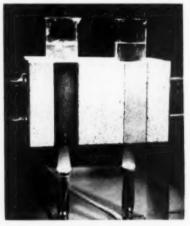
122 Central Avenue, Clark (Rahway), New Jersey Offices in principal cities PER-SOLV (Perchlorethylene) CIRCO-SOLV (Trichlorethylene) Vapor Degreasers • Metal Parts Washers • Dryers • Solvent Recovery Stills

with plating but for anyone interested in automation. The new machine, now thoroughly tested in production, makes use of uncomplicated longitudinal and vertical movements. Central hydraulic power supply and control panel may be located at any convenient point. Two sets of controls allow adjustment of speed or dwell of each movement, or skipping a station entirely. Plating baskets are transferred from one tank to the next by a variable stroke hydraulic cylinder fitted with decelerating controls.

For further information circle No. 1372 on literature request card on p. 32-B.

Heat Transfer Brick

A very good thermal conductor, high-temperature brick has been announced by the Carborundum Co. This silicon carbide material is said to have thermal conductivity comparable to



hot chromium-nickel steels, and eleven times more than fireclay refractories. It is produced as a brick, cement, or in shapes for use in heat transfer applications up to 3000° F.

For further information circle No. 1373 on literature request card on p. 32-B.

High Speed Tool Steels

Latrobe Steel Co. has announced high speed steel of regular analyses, to which have been added uniformlydistributed sulphide lubricants in a new form. Latrobe claims longer tool life for these steels, now available in M-1, M-2 and M-10 types, in all sizes and shapes normally furnished.

For further information circle No. 1374 on literature request eard on p. 32-B.

X-Ray Quantometer

Applied Research Laboratories introduced its new X-ray Quantometer at the National Metal Exposition on October 19th. This instrument performs rapid nondestructive analysis of metals, powders and liquids, by X-

New facts for your file on

U-S-S CARILLOY STEELS

special U·S·S Carilloy steel reduces the cost of critical transmission parts

• How would you like to save \$25 a ton on steel for your heavy-duty parts, without sacrificing quality? We bet you'd jump at the chance, just as the manufacturer of the Army's great Walker Bulldog Tank did.

USS Metallurgists showed him how to make this important saving. They recommended special USS developed Superkore steel for the drive gears and pinions of this powerful machine. This steel provides the required hardenability, but contains less alloy than other steels capable of doing the job. Therefore, it costs less.

Improved machinability

USS Superkore also responds more uniformly to heat treatment and is easier to machine than ordinary alloy steels of equal hardenability.

USS Superkore—now known as TS 43BV12 and adopted in both AMS and ASTM specs—is one example of the many important new developments that have come from the extensive research laboratories of United States Steel. From our constant effort to get the *most possible work* out of steel at the *lowest cost* to you, have come better steels for use at high temperatures—better steels for use at extremely low temperatures— steels that are easier to machine—steels that are easier to heat treat—steels that in hundreds of ways help to solve production problems and reduce costs.



The Walker Bulldog is a light combat vehicle weighing 26 tons. It is equipped with a new 76 mm, high-velocity gun, a 500-hp engine, and heavier armor than World War II tanks.

Free metallurgical assistance

We may have ready for use or under development just the steel you need to solve a tough production problem. If we do, the USS Service Metallurgist who contacts you will know about it. If we don't, we may be able to modify an existing Carilloy steel to suit your special requirements. In either event, it will pay to get in touch with us and find out.

If you have any question at all about alloy steels, write to United States Steel, Room 2818-X, 525 William Penn Place, Pittsburgh 30, Pa.



UNITED STATES STEEL CORPORATION, PITTSBURGH • COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO
TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA. • UNITED STATES STEEL SUPPLY DIVISION, WAREHOUSE DISTRIBUTORS
UNITED STATES STELL EXPORT COMPANY, DEW YORK



"We've got this says Joseph Asmonga,



heat treating down cold"

U.S. Steel Heat Treater



In the entire production of steel forgings, no single operation is more important or more finicky than the heat treating. Here, with careful heating and quenching, the forging is tailor-made to the physical properties you require.

At best, heat treating is a complicated business. And when you get into the giant forgings made at our Homestead Forgings Division, you encounter problems absolutely unknown in the production of smaller forgings. Only a handful of men in this country have the skill to do the job. One of them is Joseph Asmonga, a Heat Treater for 18 of the 25 years he has been with U. S. Steel.

Sheer size is a great problem and often makes liquid oil or water quenching impracticable. In the photograph, Mr. Asmonga is air quenching a roll arbor—and it takes him 10 hours just to reduce the temperature from about 1750°F. to 650°F.

Admittedly, Mr. Asmonga has an eye-popping array of instruments, furnaces and cranes to help him—as well as a complete metallurgical staff. But when you get right down to it, it takes plain old experience and skill to change a list of specifications into a finished, precisely heat treated forging.

Joseph Asmonga is typical of the men who actually do the work on your USS Quality Forgings. All of these men have the skill, the equipment and the *determination* to give you the finest steel forgings that money can buy. Write for more information and our free 32-page booklet describing USS Quality Forgings. Address United States Steel Corporation, 525 William Penn Place, Pittsburgh 30, Pennsylvania.

Quality FORGINGS heavy machinery parts — carbon, allow, stainless

electrical and

hammer bases and columns

forged steel rolls and

New facts for your file on U.S.S GARILLOY STEELS

U·S·S CARILLOY steel cushions bone-rattling jolts on the world's finest medium tank

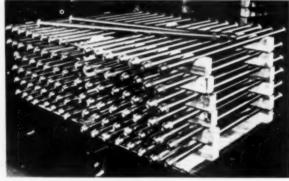
The army's amazing new Patton 48 not only moves faster, shoots straighter, and offers better protection to the tank crew, but it has a vastly improved suspension system that features torsion bar springs made of U·S·S CARILLOY steel. As a result, it rides lower and more level and with less jarring than World War II models.

During rugged field tests, this 45-50-ton tank rolls along at more than 30 miles an hour, knocks down telephone poles and houses, rumbles over deep trenches and scales 3-foot walls. All the while, the Carillov steel torsion bars that support the driving wheels flex, twist, and vibrate. They smoothly absorb most of the jolts as the tank forges ahead.

Torsion bars withstand this heavy pounding . . . and do a better job of cushioning these shocks than previous spring systems. What's more they take less space, so the tank can be built closer to the ground, has a lower silhouette than other models.

USS CARILLOY 8660 is a Ni-Cr-Mo electric furnace steel which possesses the required hardenability needed in these torsion bars. It





HERE are the Carittov steel torsion bars ready for shipment. Torsion bars are used on the Patton 48 and others so that the tanks can be built closer to the ground, giving a lower silhouette.



ON THIS TWISTER at the Cicero plant of Maremont Automotive Products, Inc., the finished Carlliov steel torsion bars are prestressed before shipment to the tank manufacturer.

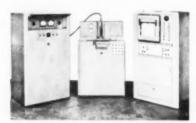
will produce a minimum hardness of 55 Rockwell "C" at $^{\circ}_{16}$ ", from the quenched end in the standard End Quench hardenability test. It has exceptionally good surface and subsurface qualities.

Both the United States Army Ordnance Corps and the spring manufacturer, Maremont Automotive Products, Inc., are well satisfied with this excellent performance. USS Carillov steels are doing many tough jobs like this on both military and civilian products. So no matter what type of steel problem you have, we have probably met and licked one very much like it before. We can help you solve yours. Just get in touch with our nearest District Office, or write to United States Steel, 525 William Penn Place, Pittsburgh 30, Pa.



UNITED STATES STEEL CORPORATION, PITTSBURGH . COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO
TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA. . UNITED STATES STEEL SUPPLY DIVISION, WAREHOUSE DISTRIBUTOR:
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

ray fluorescence spectrography, and is equally adapted to laboratory or production control problems. The circuits used in the instrument can measure a



number of elements in the time required to record one element with a scanning spectrometer. It can be supplied for use of eight channels simultaneously.

For further information circle No. 1375 on literature request card on p. 32-B.

Standardized Graphite Molds

National Carbon Co. has standardized its line of graphite pig ingot molds to permit quick deliveries.

Graphite molds are in use as over metal molds and in casting many special shapes of metals. The following advantages are claimed: low costs; smooth, clean, uniformly sized ingots with no chemical contamination; light in weight; will not erack, chip,



spall, fire-check or warp; quick stripping merely by upsetting; no preheating required; easy to machine or fit into mounting devices; and long life.

For further information circle No. 1376 on literature request card on p. 32-B.

Beryllium Copper

A new alloy that promises to spread the industrial range of beryllium copper into new fields was featured as one of the main exhibits of the Beryllium Corp. at the 35th National Metal Exposition. The new low-beryllium alloy is claimed to combine properties of high strength and high conductivity.

For further information circle No. 1377 on literature request card on p. 32-B.

Furnace Quality Controls

Indicating flowmeter controls for balancing heat input and furnace requirements have been announced by there's nothing like it!





No clamps needed with this new multiple-angle metal hardness tester — the semi-portable A18 and A20 Penetrascope units. For a combination of accuracy and versatility, there is nothing like it in American industry today.

The A-20 Penetrascope illustrated above was developed for testing the many parts and places inaccessible when clamps are used—gear teeth roots and large bearing races, for example. The Penetrascope is movably mounted on a magnetic stand, holding the unit firmly to a ferrous surface, on which the object to be tested is also set securely. Adaptability is obtained by angling the stand on the ferrous surface, by angling the Penetrascope on its stand, and by adjusting the height of the Penetrascope on the stand.

For more accessible work, the basic Penetrascope is available with a variety of C-Clamps and magnetic clamps. The Penetrascope employs a 136° pyramidal diamond indentor which is extremely accurate from 16 to 800/1000 D.P.H. Excellent comparative results are obtainable up to 1500 D.P.H.

Send for our booklet on the Penetrascope today.

PENETRASCOPE "PLUS" VALUES

- 1. Portable-basic unit weighs about 18 lbs. net.
- 2. Extremely accurate from 16 to 800/1000 D.P.H.
- Versatile—capable of conventional and multiple-angle testing of large or small pieces. Pieces can be tested at site.
- 4. Minimum Marring-not considered a destructive tester.

C. TENNANT, SONS & CO., OF NEW YORK

100 PARK AVENUE, NEW YORK 17, N.Y., U.S.A. TELEPHONE OREGON 9-1300



• You flip a switch-lights go on. You expected that. The real reason they go on, however, is because power men expect generating equipment to fail. They work, then, to prevent failure. Their success in stopping failure BEFORE it happens is often due to inspection with methods by Magnaflux.

Inspection with Magnaflux * detects defects and makes invisible cracks visible. Low cost and non-destructive inspection methods by Magnaflux are used on nearly every material in most industries for all kinds of maintenance inspection.

Also used as a production tool, Magnaflux is helping hundreds of manufacturers make better products at lower cost.

All of the facts about Magnaflux are included in an interest-

ing brochure "Seeing Isn't Always Believing. Copies are available on request.

*Magnaflux is a registered trademark of the Magnaflux Corporation



MAGNAFLUX





MAGNAFLUX CORPORATION 7346 W. Lawrence Avenue, Chicago 31, Illinois

New York 36 * Pittsburgh 36 * Cleveland 15
Detroit 11 * Dallas 9 * Les Angeles 58

Seico Instruments Div. of Grindle Corp. These custom controls are claimed to limit temperature differences of pieces in the furnace and enable proportioning of heat input to the changing rate of heat absorption. The two instruments in this control system can be adapted for either manual or automatic operation.

For further information circle No. 1378 on literature request card on p. 32-B.

Microscope Reader

The Pacific Transducer Corp. has announced a new Brinell microscope reader for the measurement of inden-

tation diameters for determining hardness and checking the accuracy of harness testing machines. This new 20-power microscope features a reticle in a flatfield optical system, and a selfenclosed concentrated beam of light. The 7-mm.



scale is graduated in tenths of millimeters.

For further information circle No. 1379 on literature request eard on p. 32-B.

Cut-Off Machine

The Stone Machinery Co. announces a regular cut-off machine that can be converted quickly for free-hand cutting of gates and risers from nonferrous castings. The machine is shown

set up for freehand cutting. As a regular cut-off machine, either abrasive or tool steel blades may be used. Capacity is 2½-in. solids, and 4-in. pipe, tubing and structurals. This machine can cut ma-



terials at less than 4 sec. per sq. in.

For further information circle No. 1380 on literature request card on p. 32-B.

Tool Cooling

A new coolant has been announced by the Air Conversion Research Corp. This portable unit can accommodate up to 16 cutting operations. It operates on the expansion-cooling of gas refrigeration principle. Coolant is forced into a high velocity air stream where it is atomized into a fine mist, It is then directed to the tool through

MARTINDALE

ROTARY BURS AND FILES

Made of high-speed steel. Produced in our own factory where uniform hardness is assured by heat-treating in electric furnaces on which the temperature is closely controlled by electric eyes.





The above sets, with 1/4" diameter shanks, are composed of the 8 most popular sizes for gen-

Over 200 sizes and shapes (total over 75,000 ieces) are carried in stock for immediate

DEMAGNETIZER—Model D-3



This tool quickly and easily removes magnetism from cutting tools such as cutters, drills, saws, etc., and thus keeps them free from chips and metal-slivers that reduce production. Cuts cost

HEAVY DUTY ETCHER



Model A-A has wide use as a production-line etching tool. With six heats it is effective on small parts and also on large pieces such as shovels, castings, etc. Complete with ground lead, heavy metal case, etc.

Send for new Catalog No. 29 with 64 pages of Maintenance, Production and Safety Equipment.

MARTINDALE ELECTRIC CO.

1372 Hird Avenue, Cleveland 7, Ohle

Metal Strippers

METAL STRIPPER

An alkaline stripper that dissolves nickel, copper, zinc, cadmium and silver without attack on steel or stainless steel.

METAL STRIPPER

Used in acid solutions to strip nickel, zinc, iron, cadmium, lead and tin without attacking basis metals of copper, brass, silver and gold.

TIN-LEAD STRIPPER

Dissolves tin, lead and solder from basis metals of copper, brass, steel, stainless steel, nickel, silver and gold. Alkaline in nature.

ZINC STRIPPER

An alkaline stripper for fast stripping of zinc from steel and copper.

ZINC DIE CAST

Compound L-88, an electrolytic acid stripper to strip chromium, nickel, copper and brass from zinc base die castings without pitting the basis metal.

Write to Enthuny As-

ENTHONE

METAL FINISHING PROCESSES

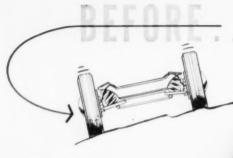
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ELECTROPLATING CHEMICALS

SERVICE REPRESENTATIVES AND STOCK POINTS

ARDCO, INC. 5000 West 73rd Street Chicago 38, Illinois R. O. HULL & COMPANY 1300 Parsons Court Rocky River, Ohio

L. H. BUTCHER COMPANY 3628 East Olympic Blvd. Los Angeles, California



Weeks of actual use were the only way Socony-Vacuum could test quality of grease

NOW...

Socony-Vacuum's pilot plant cuts testing time to a matter of minutes—often eliminates several weeks' output of unusable product. The RCA Table Model Electron Microscope contributes substantial time savings to this operation—permits specimen testing in just a few seconds. (In background, microphoto of suitable batch.)

Socony-Vacuum cuts weeks to minutes with RCA Electron Microscope

In a new quality-control operation, Socony-Vacuum Oil Co. now eliminates time lags—and wasted production—in a pilot operation built around the RCA Electron Microscope Model EMT-3. With this equipment, Socony-Vacuum research men actually cut weeks of test time to the few minutes required to prepare and photograph a sample.

For a small investment Socony-Vacuum has obtained the dual advantages of electron-microscopy—high resolution and high magnification (40,000 X photographically).

Perhaps the RCA Type EMT-3 Electron Microscope can help you to control quality ... determine the structure and composition of raw materials . . . cut costs . . . save time . . . accelerate development of new products. Check these important advantages:

Instant Photography and Specimen Changing —20 exposures without breaking vacuum—with new roll film camera.

Permanent - Magnet Lenses — offer exceptional stability for the most exacting studies.

50-KV Accelerating Voltage comparable to that offered in larger, higher-priced equipment.

Accurate Focusing—with new focusing magnifier and viewer,

for Information

on the RCA Electron Microscope (EMT-3) and RCA's training assistance program, write Scientific Instruments, Dept. 104W, Radio Corporation of America, Camden, N. J.



RADIO CORPORATION OF AMERICA ENGINEERING PRODUCTS DEPARTMENT, CAMDEN, N. J.

In Canada: RCA VICTOR Company Limited, Montreal

- Electron Microscope
- · Vacuum Units
- Shadow Caster
- Vacuum Leak Detector
- Electron Diffraction Equipment

a centrifugal distributor, flexible high-pressure tubing and nozzle. The coolant solution is cooled below room temperature and cools the tool; the jet action carries away tool heat and keeps chips out of the way.

For further information circle No. 1381 on literature request card on p. 32-B.

Stereoscopic Microscope

To permit greater speed, convenience and versatility in stereoscopic microscope work, the Galileo Co. has announced three exclusive design improvements in its stereoscopic micro-

scope: A 180° rotating binocular head, a three-way stand, and a novel quick-change nosepiece. The rotating binocular head is inclined at a comfortable 30° angle and turns on



a vertical axis to permit either normal or inverted observation. The stand sits extra low for greater comfort and convenience. The microscope will accept objects up 11 cm. high. If the base support is removed, the unit can be placed directly on the object to be examined.

For further information circle No. 1382 on literature request card on p. 32-B.

Vacuum Melting

U. S. Patent 2.625,719 has recently been granted to the National Research Corp. covering continuous vacuum melting furnaces. This new development makes it possible to charge raw material and remove vacuum-cast ingots from furnaces without the necessity of cooling the crucible or breaking the vacuum in the melting chamber,

For further information circle No. 1383 on literature request card on p. 32-B.

Spectrograph

A versatile new 1.5-meter stigmatic grating spectrograph designed to bring precision spectrography within



the reach of small firms, has been announced by the Bausch & Lomb Optical Co. The instrument is avail-



WAUKEE FLO-METERS

. . for measuring industrial gases

Here at last is the truly modern flo-meter that offers important and exclusive advantages for every user.

- Easy to clean. No tools are needed for disassembly . . can be completely cleaned and reassembled in 2 minutes.
- Easy to read. 6" scale gives extra visibility. Exclusive Wankee tabs identify in large red letters gas being measured. Eliminates mistakes.
- 3. Built-in control valves. Operators can easily see flow change.
- 4. Easy to mount. Can be panel mounted
 ... piping is simpler, installation
 costs less

For additional information request bulletin 201.

Maukee

ENGINEERING COMPANY

403 E. Michigan St., Milwaukee, Wis.



"To sum it up, chief, we can do it if we use Columbia MAXITE Tungsten-Cobalt High Speed Steel."

COLUMBIA TOOL STEEL COMPANY . CHICAGO HEIGHTS, ILL.

Producers of fine tool steels—High Speed Steels Die Steels—Hot Work and Shock Resisting Steels Carbon Tool Steels,



able in two models which provide different dispersions, resolving powers and plate coverages. Both are capable of analyzing a wide range of materials. For ease in manipulation, all parts are located at the same end of the instrument. Exposure time of several seconds provides a high degree of sensitivity for trace elements.

For further information circle No. 1384 on literature request card on p. 32-B.

Consumable-Electrode Gas-Shielded Welder

New welding equipment for the consumable-electrode, gas-shielded welding process has been announced by the General Electric Co. Called Fillerarc, the apparatus is expected to advance the field of application of highspeed, high-current-density, gasshielded welding, which heretofore has been hampered by the necessity of using existing welding generators not specifically designed for this process. Electrode wire of aluminum, stainless steel, mild steel, copper, magnesium and other alloys may be employed in the Fillerarc equipment with argon or helium shielding gas. The process can be used in downhand, vertical, or overhead positions to weld aluminum of any alloy in thicknesses from 1/32



to 3 in., and stainless steel from $\frac{1}{10}$ to 1 in. It is also suitable for welding aluminum bronze, nickel and magnesium.

Fillerare equipment consists of three main components: a special self-regulating motor-generator type welder, a pistol-like holder, and an electronic wire-drive unit. The generator is unlike any others used in this process. Rated at 450 amp. continuously, it has a rising volt-ampere characteristic. As current is produced, the voltage generated increases, making the process completely self-regulating. Designed to give constant are length, the new welder produces any current required up to its full rating. Thus, it is prepared for any wire

feeding speed and will supply the current necessary to melt off the wire at exactly the rate it is fed. Machine settings are for arc length only; no current calibrations appear on the dial.

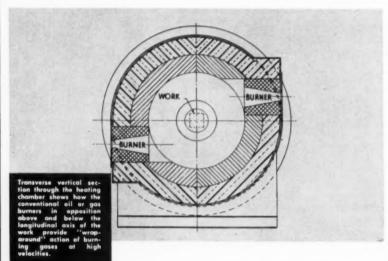
The Fillerarc gun contains knurled feed rolls for pulling the electrode wire from a spool mounted in the wire drive unit, a trigger to control wire feed and gas flow, and an electrical contact tip. It is water cooled with a rating of 400 amp. continuous d-c. The gun is capable of feeding wire from 0.030 to 0.093 in. in diameter. The feed can be adjusted from 0 to 750 in. per min., and the set speed is held constant by an electronic motor

control in the wire drive unit. Fingertip control provides gas coverage before and after arc is struck.

For further information circle No. 1385 on literature request card on p. 32-B.

Cut Wire Shot

Shot cut to form cylinders of a length equal to the diameter of the wire has been announced by Harrison Abrasive Div. Uniformity of size means that each particle provides the same impact and the same finish without the wasted energy of throwing shot, without producing the desired results. This L/D cut-wire shot is available in steel, copper and stain-



IR=S hi-head heating system

R-S Hi-Head[®] Heating System prepares bars, slabs, pipe, tubing, and other forms of long, straight stock for forging or heat treatment to meet the most Rigid Standards.

Initial costs are less than with conventional multiple unit methods. Economies are achieved through high speed operation and volume production. Labor costs are reduced as much as 75%.



R-S FURNACE TYPES

Hi-Head Batch Rotary Hearth Continuous

Belt Conveyor Continuous Chain Continuous

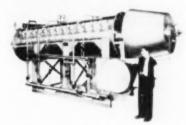
Pusher Continuous Pusher Tray Pit Continuous Roller Hearth Car Hearth

less steel in a range of wire diameters from 0.0625 to 0.020 in. in various length-to-diameter ratios, and with a minimum hardness range of 36 to 46 Rockwell C, depending on the wire diameter.

For further information circle No. 1386 on literature request card on p. 32-B.

Control Zones Furnace

Three separate zones of temperature control is an outstanding feature of the latest rotary retort furnace built by American Gas Furnace Co. External controls permit the operator to regulate the temperature at will in any one of the three zones, divided about equally over the length of the furnace. This permits "on and off"



operation during the idling periods, very high input when producing work, and variation for special heating needs. Up to 1000 lb. of nonferrous parts per hour can be handled by the heated work space, which is 15 in, in diameter by 10 ft. long.

For further information circle No. 1387 on literature request card on p. 32-B.

Heat Treating Pots

Pressed steel pots for heat treating furnaces, metallized to give up to 200% longer life, have been announced



by the Eclipse Fuel Engineering Co. These new pots are available with metallized coatings for temperatures up to 1500° F.; from 1500 to 1700° F. and for 1700° F, and over.

For further information circle No. 1388 on literature request card on p. 32-B.

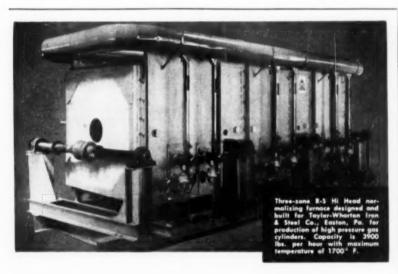
Cleaner

Detrex Corp. has developed a new metal cleaner especially for the vitreous enameling industry. The cleaner is a medium-high alkaline compound with high wetting and penetrating properties. It will emulsify large quantities of mineral oils and greases and keep them in suspension.

For further information circle No. 1389 on literature request card on p. 32-B.

Accelerated Salt Bath Quench

A simple method of sharply improving both the quenching and tempering action of salt baths-without cost-was demonstrated publicly for the first time by American Cyanamid Co. at the Metal Show, Water added to a nitrate-nitrite bath while it is in a molten state results in the following advantages: (a) it will operate at temperatures lower than 275° F. while other baths are limited to 300" F.: (b) the bath maintains its original composition for long periods of time below the mixture's boiling point; (c) martempering and hot-quenching operations take place at accelerated quenching rates; (d) specific degrees of hardening may be obtained by altering the amount of water in the bath, a unique characteristic since the controlling factor is the bath composition rather than the alloy content of the steel; (e) the bath can be easily restored to the more conventional type by raising its temperature to eliminate the water; (f) the new type bath involves no added costs. Water



produces to Rigid Standards

Rigid Standards are met by the rapid and uniform heating. A steel billet 3½ inches square (regardless of length) can be heated to 2300° F. in 14 minutes with uniform heat conduction to the interior of the billet. The "wrap-around" action of the burning gases at high velocities and the high thermal head produce rapid heat transfer.

R-S FURNACE CORP.

4555 GERMANTOWN AVENUE PHILADELPHIA 44, PENNSYLVANIA

A SUBSIDIARY OF HARDINGE COMPANY, INC.



can be added without violent splattering if the bath is agitated and below 350° F., despite the fact that this is more than 100° F, above the temperature at which water turns to steam. Nitrate and water molecules apparently become bonded before the water reaches the boiling point. The development represents an unusual exception to a widespread safety practice in the metals industry which calls for water always to be kept away from molten salt baths. The exception is made possible only by following detailed recommended procedures.

For further information circle No. 1390 on literature request card on p. 32-B.

Ceramic Coatings

The General Ceramics and Steatite Corp. announces the availability of several ceramic coatings and enamels, for application to various alloys and aluminum. Samples will be available for evaluation of such properties as oxidation protection, high temperature insulation, and radiant energy reflectance.

For further information circle No. 1391 on literature request card on p. 32-B.

Sprayed Insulation

A new quick-drying material that can be sprayed like paint on metal making the treated surface capable of withstanding temperatures as high as 5000° F. has been announced by B. F. Goodrich Co. A 1/16 in. coating of the new insulation protects metal for as long as 10 sec. against flame

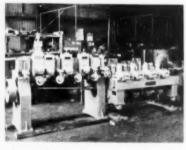


temperatures hotter than the melting point of metals. Pyrolock is described as a water-base inorganic material. It is nontoxic, nonflammable, nonexplosive and will adhere directly to clean metal surfaces without sandblasting or use of priming surface preparations.

For further information circle No. 1392 on literature request card on p. 32-B.

Straightening Machine

The Medart Co. has released details on a new shape-straightening machine, a two-plane variable-center type, incorporating overhung rolls



which allow quick roll change from one shape of workpiece to another. All of the rolls may be moved independently to allow set up with any given bending span up to the length of the bed. Feeding and re-forming are accomplished by simply moving one roll directly opposite another.

For further information circle No. 1393 on literature request card on p. 32-B.

High-Purity Carbon for Spectrographic Analysis

A high-purity spectrographite rod for critical chemical and metallurgical analysis by the spectrographic process has been announced by the Stackpole Carbon Co. The new PG4 rod has less than 0.001% of impurities. It is supplied in lengths up to 12 in. and in diameters of ½, Å, ¼ and ¾ in.

For further information circle No. 1394 on literature request card on p. 32-B.





Sentry 4Y Installation at Parker-Kalon Corporation, New York, N.Y.

Harold Rosenberg, Works Manager at Parker-Kalon in New York, says: "We have been using our Sentry Furnaces on a multiple-shift basis for more than 15 years. Throughout that period we have relied on Sentry for all of our high speed, high carbon and high chrome tool steels. It's gratifying to know that we can depend on Sentry to help us maintain our famous P-K quality."



INDUSTRIAL ELECTRIC FURNACES AND EQUIPMENT FOR HEAT TREATMENT OF METALS



1405. Abrasion Tester

Bulletins on durable precision instrument for testing resistance of surfaces to abrasion. Taber Instrument

1406. Abrasive Belt

Folder on belt for finishing carbide tools.

Behr Manning

1407. Abrasive Testing

Bulletin No. 6 on methods of running production tests on metal abrasives. Harri-son Abrasive Div.

1408. Adhesives

Bulletin describes polyurethanes and their use in bonding steel to steel, alumi-num to aluminum, magnesium to alumi-num. Monsanto Chemical

1409. Allov Steel

16-page book on type 9115 low-alloy high-strength steel. Properties, fabrica-tion, welding. Great Lakes Steel

Alloy Steel

Data book on the selection of the proper alloy steel grades for each manufacturer's needs. Wheelock, Lovejoy

1411. Alloy Tools

44-page book on cast Stellite tools for metal cutting. Haunes Stellite

Aluminum Bronze

Bulletin 33 on properties and uses of Ampco metal. Ampco

Aluminum Die Castings Bulletin on design and manufacture of aluminum die castings. Hoover Co.

Aluminum Extrusions

28-page book on extruded aluminum products. Design, tolerances, applications.

Aluminum Extrusions Data on services in the field of alum-inum extrusions, Himmel Bros. Co.

1416. Aluminum Strip

20-page book gives technical data on five grades of aluminum strip. Scovill

1417. Ammonia Atmospheres 12-page bulletin B-52 on dissociated ammonia furnace atmospheres. Drever

Ammonia Dissociators

Bulletin on dissociating process gives advantages of ammonia as controlled at-mosphere. Sargeant & Wilbur

1419. Ammonia for Heat Treat

Booklets on "Applications of Dissociated Ammonia", "Ammonia Installations for Metal Treating", "Nitriding Process", "Carbonitriding". Armour

1420. Analysis of Nickel

52-page Technical Bulletin T-36, "Methods for Chemical Analysis of Nickel and High-Nickel Alloys". International Nickel

1421. Anodizing

Data on aluminum racks with copper hooks for anodizing. National Rack

1422. Anodizing Magnesium

Article on a new anodic coating for magnesium. Dow Chemical

1423. Are Welding

8-page reprint on weld tests on mild cel welded with inert-gas metal-arc

Atmosphere Furnace

Bulletin on controlled atmosphere furnace. Industrial Heating Equipment

1425. Atmosphere Furnace
Booklets H 53-8 on batch-type radiant
tube furnaces for gas carbwizing, marquenching, dry cyaniding, and other heattreating operations. Surface Combustion

1426. Atmosphere Generators

12-page booklet on gas producers de-scribes equipment and gives data on com-position and applications of atmospheres. Bellevue Industrial Furnace

1427. Automatic Polishing

14-page, illustrated brochure describes automatic equipment for polishing, buffing and grinding. Murray-Way

1428. Barrel Finishing

32-page handbook on compounds for descaling, deburring, coloring, metal cleaning and rust inhibition, Lord Chem-

1429. Bending and Cutting

Folder describes hand and air-operated bender-cutter and its applications. J. A. Richards

1430. Blackening Compounds

Bulletin on blackening compounds (for ferrous alloys) to AMS Spec 2485. Swift Industrial Chemical

1431. Black Oxide Coatings

Data on black oxide coatings for steel, stainless steel and copper alloys, Du-Lite

1432. Black Oxide Finish

Folder on penetrating black finish for ferrous metal. Puritan Mfg.

1433. Black Oxide Finish

Four-page article "Low-Cost Black Oxide Finish on Steel by Chemical Dip Method". Mitchell-Bradford

1434. Blast Cleaning

24-page Bulletin 400 on blast cleaning installations for large work. Pangborn

1435. Brazing Titanium

Data sheet on use of a new flux for brazing titanium. Handy & Harman

1436. Bright Annealing

Reprint on bright annealing of copper in atmosphere furnace. Holcroft

1437. Bright Carburizing

Job data on bright carburizing and hardening gears. Ipsen

1438. Bronze

12-page bulletin on properties and uses of continuous cast bronze rod and tube. American Smelting & Refining

1439. Burner

Catalog 410 describes proportioning oil burner. Hauck

Burners

Bulletin on combination gas and oil burner. Ra-Diant Products

1441. Carbon Analysis

Folder describes method of rapid carbon determination. Leitz

1442. Carbon and Graphite

20-page catalog on carbon and graphite applications in metallurgical, electrical, chemical and process fields. National Car-

1443. Carbonitriding

Bulletin 241 on gas-fired radiant-tube furnace for carbonitriding and other heat treating. Lindberg Engineering

1444. Carburizing

Data folder on Aerocarb E and W water-soluble compounds for liquid carburizing. Case depth vs. time curves. Per cent car-bon and nitrogen penetration curves. American Cyanamid

1445. Casting Specifications

Design values for five grades of heat resistant castings. Ohio Steel Foundry

1404. Nonferrous Alloys

A large body of specification data on nonferrous ingots and castings has been assembled in the newly released 1953 edition of the Specification Data Book. The spiral-bound 84-page book presents in three sections data on brasses and bronzes, aluminum



alloys, and lead, solders and babbitts. Each section begins with a table which compares Federal, Navy, Military, ASTM and SAE specifications at a glance. Detailed composition and property data for each specification appear on the following pages of the sections. Tabbing the sections has made the book easy to use. Colonial Metals

1446. Castings, Bronze

16-page booklet on sand and centrifugal castings. Amer. Non-Gran Bronze

1447. Centrifugal Castings

62-page book on centrifugally cast iron, steel, gray iron parts. ASTM specifications. American Cast Iron Pipe

1448. Chromate Coatings

Folder gives characteristics and uses of chromate conversion coatings on non-ferrous metals. Allied Research AIR HARD

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Manganese oil hardening...general purpose die steel ... specially

annealed for good machinability... Iow movement

in hardening.

5% chromium air hardening die steel . . . high strength . . . high wear resistance . . . good machinability.

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steel . . . oil or air hardening

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hardening.

cold work

These Die Steels for Cold Work are designed to cover every performance requirement, and for adaptability to available heat treating facilities. Each grade is carefully annealed and fully inspected by magnaflux, reflectoscope and deep etching to insure First Quality selection. Our Representative in your, area will gladly assist you with your needs.

Write for your free copy of our detailed metallurgical brochure on "Die Steels for Cold Work."

Vanadium-Alloys

STEEL COMPANY

LATROBE, PA.

COLONIAL STEEL DIVISION . ANCHOR DRAWN STEEL CO.



1449. Cleaners

12-page catalog on metal cleaners. Table f recommended practices. Klem Chemi-

Cleaning

Bulletin on equipment for cleaning and pickling of shell cases and other ordnance items. Alvey-Ferguson

1451. Cleaning Compounds

16-page manual on finishing method for deburring and burnishing small metal parts. Compounds for heat treat scale removal and rustproofing, Minnesota Min-

1452. Cleaning Equipment

Folder on degreaser. Data on different models. Circo Equipment

1453. Cold Finished Bars

Engineering bulletin, "New Economies in the Use of Steel Bars". LaSalle Steel

Cold Finished Steel

8-page bulletin on selection, use, rela-tive cost of cold finished carbon steel bars.

Combustion

Bulletin AD-607 on oxygen index of combustion processes. Arnold O. Beckman

Compressors

12-page bulletin 126-A on application of turbo compressors to oil and gas-fired equipment used in heat treating, agitation, cooling, drying. Performance curves, ca-pacities. Spencer Turbine

1457. Continuous Casting

24-page book, "Better by the Mile", describes how the Rossi continuous casting machine works. History of continuous machine works. Hi casting, Scovill Mfg.

1458. Copper Alloys

64-page book on free-cutting brass, cop-per and bronze. Chase Brass

1459. Core Oils

Bulletin describes core washes and binders. Pelron core oils, pastes,

1460. Corrosion Resistance

35-page booklet on plastic materials of construction. Atlas Mineral Products

1461. Cut-Off Wheels

Folder gives data, operating suggestions and grade recommendations of cut-off wheels. Manhattan Rubber Div.

1462. Cutting Compounds

Data on cutting compounds for stain-less and titanium. Hangsterfer's Labs.

1463. Cutting Fluids

Cutting and grinding fluid selector for various machining operations. D. A.

1464. Cutting Oil

Facts on more efficient and economical plant operation through use of right lubri-cants described in "Metal Cutting Fluids" booklet. Cities Service

1465. Cutting Oil Chart

Selection chart for seven classes of metal n nine machining operations, Aldridge in nine machi

Descaling Stainless Steel

Bulletin 25 on descaling stainless steel nd other metals in molten salt. Hooker Electrochemical

1467. Die-Casting Machines

22-page catalog shows complete line of die casting machines. Kux Machine

1468. Die Sets

24-page catalog on all steel die sets and supplies. Superior Steel Products

1469. Electric Furnaces

Brochure on electric heat treating, melting metallurgical tube, research and sintering furnaces. Pereny Equipment

1470. Electrical Steel

80-page book of engineering data on silicon steels for the electrical industry. Republic Steel

1471. Electron Microscope

New 20-page brochure describes in de-tail ten case histories in which the electron microscope has been at work solving problems of development and control in industrial laboratories, RCA

1472. Electroplating

Folder on new process for electroplating intricate precision parts with precious or common metals at controlled tolerances. American Electro Products

Enamel on Aluminum

Bulletin 2001 on application of porcelain enamels on aluminum alloys. Procedures in selection of alloys, application of enamel, correction of defects. Pemco

1474. Extruded Cylinders

Bulletin on extruded steel cylinders ith smooth surfaces and no taper. Mulwith smo

1475. Extrusion Presses

8-page bulletin on presses designed for extrusion of aluminum, brass and other nonferrous metals. Lake Erie Engineering

1476. Fasteners

68-page catalog of screws, bolts, nuts, washers. Interstate Screw Corp.

1477. Fatigue Testing

12-page bulletin on Schenck universal dynamic fatigue machines for oscillating reversed stress, push-pull fatigue testing,

torsion tests, single-direction and endurance life tests. R. Y. Ferner Co.

1478. Filters

8-page bulletin on dimensions and ca-acities of industrial filters. Industrial

1479. Finishing

Book, "Abrasive Grain and Powders for Use in Metal Finishing". Abrasives Div., Carborundum

1480. Finishing

52-page book "Advanced Speed Finishing" describes equipment for deburring and finishing. Almco Div.

1481. Finishing

Catalog A-653 gives complete story on planning industrial finishing systems and shows many installations of cleaning and pickling machines. R. C. Mahon

Finishing Compounds

8-page booklet on compounds for barrel finishing. Methods of deburring, surface finishing and precision finishing. Min-nesota Mining and Mfg.

1483. Finishing Systems

Bulletin on cleaning and rust-proofing equipment, spray booths and drying ovens. Peters-Dalton

1484. Flaw Detection

Illustrated bulletin on Spotcheck, new dye-penetrant method for locating surface defects. Magnaflux

1485. Flow Meters

16-page catalog on meters for flow rate measurement of liquids and gases by vari-able area method. Fischer & Porter

1486. Flow Meters

Bulletin 201 on flow meter for gas used in heat treating. Waukee Eng'g



1487. Flow Meters

24-page manual on application and in-stallation of indicating flow meter. Meriam Instrument

Flux, Aluminum Melting

Data sheet on four fluxes for degassing and purifying aluminum alloys. Atlantic Chemicals and Metals

1489. Forgings

20-page Catalog 51 on various types of forgings, their strength and related data. Tables, drawings. Merrill Bros.

1490. Forgings

32-page engineering manual of brass and aluminum forgings. Mueller Brass

1491. Forgings

Handsome 32-page brochure on large

forgings for turbine shafts, rotors, drop hammer anvils, rolls. U. S. Steel

1492. Forming

86-page book on equipment and process of cold roll-forming. Wide sheets, narrow trim, tubular shapes, curving, coiling, tooling needed. Yoder

1493. Forming Dies

Data on roller dies for forming tubes and rolled shapes. American Roller Die

1494. Forming Dies

Folder on styles of forming dies for stainless heads-in wide range of sizes and gages. Carlson

1495. Forming Jaws
Bulletin on Hydra-Curve jaws with
flexible action for sheet forming. Hufford
Machine

1496. Foundry Practice

Article on why castings are lost; from "Lavingot Technical Journal". Lavin

Foundry Wash

Bulletin on zirconite all-purpose paste wash for foundry applications.
Alloy Mfg.

1498. Furnace Belts

44-page catalog describes metal belts for quenching, tempering, carburizing and other applications. Ashworth Bros.

1499. Furnace Controls

Bulletin on instruments and controls for heat treating furnaces. Hays Corp.

1500. Furnace Fixtures

16-page catalog on baskets, trays, fix-tures and carburizing boxes for heat treating. 66 designs. Stanwood Corp.

1501. Furnace Maintenance

16-page "Maintenance Guide for Elec-tric Heat Treating Furnaces" on preven-tive program. Hevi Duty Electric

1502. Furnaces

Reprint on forming and heat treating spring harrow teeth at Mid-West Forge & Mfg. Co. Flinn & Dreffein

1503. Furnaces

40-page book describes gas and electric furnaces and applications. Four basic types of atmospheres, Glossary of heat treating terms. Westinghouse

1504. Furnaces
Folder describes complete setup for heat treatment of small tools, including draw furnace, quench tank and high temperature furnace. Waltz Furnace

Furnaces

12-page Catalog I-2 on method of at-mospheric control for hardening high speed steel. The Sentry Co.

1506. Furnaces

High temperature furnaces for temperatures up to 2000° F, are described in bulletin. Carl-Mayer Corp.

1507. Furnaces, Heat Treating

12-page bulletin on conveyor furnace, radiant tube gas heated, oil or electrically heated. Electric Furnace Co.

1508. Furnaces, Heat Treating Bulletin on fuel and electric furnace for heat treating. Dempsey

1509. Furnaces, Heat Treating Catalog on furnaces for tool room and general purpose heat treat. Cooley

1510. Furnaces, Laboratory

26-page "Construction of Laboratory Furnaces" contains many diagrams, charts, tables, and information on how to construct furnaces. Norton Co.

Gamma Radiography

Data file on equipment and sources for cobalt 60 radiography in industry. Technical Operations

1512. Gold Plating

Folder on salts for bright gold plating. Also lists equipment needed. Sel-Rex

1513. Graphite Electrodes

164-page vest-pocket data book on graphite electrodes and electric-arc furnace practice. International Graphite

1514. Graphite Electrodes

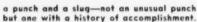
Vest-pocket notebook containing 90 pages of information on electric furnace electrodes and other carbon products. Great Lakes Carbon Corp.

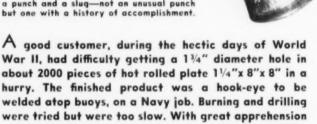
1515. Hardening Stainless

24-page "Story of Malcomizing" de-scribes surface hardening of stainless steels. Lindberg Steel Treating Co.

Among a Tool Steel Salesman's Souvenirs.







a punch and die were made, using Ziv's PLANCHER Tool Steel. The 2000 holes were promptly punched, cold, without a hitch, and both punch and die were good for a good many more.

While you may not be punching 11/4" thick hot rolled plate, you may have other jobs calling for a tough, resifient tool steel, built to be tough, real tough, then it is wise to use Ziv's PLANCHER Silicon Manganese Tool Steel.



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1516. Hardness Tester

Circular on portable hardness tester in zes for work 1 to 6 inches round and sizes for work 1 to flat. Ames Precision

1517. Heat Resisting Alloy

Pyrasteel bulletin describes chromium-nickel-silicon alloy for service economy in resisting oxidation and corrosion to 2000° F. Chicago Steel Foundry

1518. Heat Treating

72-page catalog on carburizing, cyaniding, brazing, austempering and annealing processes. Ajax Electric

1519. Heat Treating Aluminum

Bulletin on furnaces for aging, annealing, heat treating and forging aluminum.

Morrison Eng'g Corp.

1520. Heat Treating Ammonia 24-page "Guide for Use of Anhydrous Ammonia" describes heat treating and other metallurgical uses. Nitrogen Div., Allied Chemical & Dye

Heat Treating Fixtures

24-page catalog on heat and corrosionresistant equipment for heat treating and chemical processing. 30 classifications of equipment. Pressed Steel

Heat Treating Fixtures

24-page catalog B-8 on muffles, retorts, baskets, other fixtures for heat treating in gas or salt baths. Rolock

1523. Heat Treating Guide

Chart guide constructed on slide rule principle for simplified hardening and drawing of tool steels. Carpenter Steel

1524. Heat Treating Stainless

84-page book on heat treating stainless teels, both martensitic and austenitic. Republic Steel.

1525. High Speed Steel

8-page bulletin on M-2 type high speed steel. Latrobe

1526. **High-Temperature Alloy** Property data for 21% Cr, 9% Ni heat-resistant alloy. Electro-Alloys Div.

1527.High-Temperature Alloys

"Haynes Alloys for High-Temperature Service" summarizes all available data on 10 super-alloys and lists physical and mechanical properties of two newly de-veloped alloys. Haynes Stellite

1528.High-Temperature Allovs

High temperature work sheet provides valuable suggestions for solving high temperature problems in design and production. International Nickel

1529. **High-Temperature** Steels

87-page book on factors affecting high-temperature properties. 45 pages of data on tensile, creep and rupture properties of 21 high-temperature steels. *U. S. Steel*

1530. High-Tensile Steel

Bulletin on nickel-copper steel of low-alloy, high-strength type. Youngstown Sheet and Tube

1531. Hole Punching
Catalog H on horizontal hole punching
units. Wales-Strippit

1532. Hydrogen Atmosphere

Bulletin on equipment for supplying hydrogen with oxygen content less than one part per million and dew point to one part per million -70° F. Baker & Co.

Identifying Stainless

Cardboard chart outlining systematic method for rapid identification of un-known or mixed stocks of stainless steels. Carpenter Steel

1534. Illium

Data on corrosion resistance, strength and workability of Illium alloy. Illium

1535. Impregnation of Castings

Literature on new impregnating equipment for elimination of porosity in fer-rous and nonferrous castings. Metalliz-ing Co. of America

1536. Indicators

22-page catalog ND42 on manually op-erated indicators for temperature, elec-trolytic conductivity and pH measure-ments. Leeds & Northrup

1537. Induction Heating

60-page catalog tells of reduced cost and increased speed of production on harden-ing, brazing, annealing, forging or melt-ing jobs. Ohio Crankshaft

1538. Induction Heating
Catalog of heaters, their applications and operation. Weltronic

1539. Induction Heating

Book contains selector chart and heating and melting speeds for induction equip-ment. Ajax Electrothermic

Induction Heating

Data folder on megacycle tube-type machines for soldering, brazing, harden-ing. Sherman Industrial Electronics

1541. Induction Heating

Folder on electronic heaters in a selection of frequencies. Scientific Electric

1542. Induction Melting

8-page article describes use of induction melting in improved technique for rotorcasting. Ajax Engineering

Instruments

104-page catalog 450 on instruments for industry with section on engineering data.

1544. Instruments

28-page catalog No. 5000 describes in-struments, control devices and related components manufactured by the company. Minneapolis-Honeywell

1545. Insulation

Boder Scientific

8-page catalog on industrial insulation, refractories, packings and gaskets and other industrial products. Johns-Manville

Laboratory Furnaces Data sheets on complete line of labora-ory furnaces for metallurgical operations.

1547. Laboratory Furnaces

Folder describes and illustrates tubular furnace for use in tensile testing, and control panels. Marshall Products

Laboratory Safety

48-page book includes data, techniques and equipment, with useful manual for setting up complete laboratory safety pro-grams. Fisher Scientific

1549. Leak Detector

16-page bulletin on leak detector for location and measurement of leaks in evacuated or pressure systems. Consolidated Vacuum Corp.

1550. Lubricant

Uses of colloidal graphite for hot metal-working operations (deep piercing, forging, stretch forming and wire drawing operations). Acheson Colloids

1551. Lubricant

New literature on anti-seize molybde-num disulfide lubricant. Bel-Ray

1552. Lubricant

8-page folder describes use of molyb-denum disulfide lubricant in cold form-ing, cold heading and other applications. Case histories. The Alpha Corp.

1553. Machining Costs
12-page "Relation of Machining Time to
Material Cost". Comparative machinability costs per ton for eleven steels. La Salle Steel

1554. Magnesium

Dimensions, analyses, property data of magnesium plate and sheet. Brooks &

Magnesium

42-page booklet on wrought forms of nagnesium. Includes 31 tables. White Metal Rolling & Stamping

1556. Malleable Iron

12-page Bulletin 5797 on electric furnace annealing of malleable iron, General Elec-

Mechanite Gears

Characteristics of Mechanite which make it good gear material, design of gears, applications. Mechanite Metal Corp.

Melting Aluminum

Bulletin 310 on furnaces for melting aluminum. Lindberg Eng'g.

Metallizing

New bulletin on applications of metal-spraying and torch-fusing method of hard surfacing. Metallizing Engineering

Metallograph

Bulletin on camera microscope and metallograph. United Scientific

1561. Metallurgical Apparatus

200-page catalog of metallurgical ap-paratus: cutters, grinders, mounting presses, polishers, metallographs, microscopes, cameras, testing machines, analytical apparatus, spectrographs, furnaces, accessories and supplies, and 250 recommended metallurgical books. Buehler Ltd.

Microhardness Tester

Bulletin describes the Kentron micro-hardness tester. Kent Cliff Laboratories

Microhardness Tester

Bulletin DH-114 on Tukon hardness testers in research and industrial testing. Wilson Mechanical Instrument

1564. Microphotometers

12-page catalog on microphotometers for pectrographic and other uses. Leeds &

1565. Micro Polishing

10-page brochure on units for polishing coils, blanks and sheets. Murray-Way

Modulus Determination

Data sheet on equipment for determination of modulus of elasticity by sonic method that measures resonance frequency of masses weighing up to 1500 lb. Electro Products Laboratories

Moly-Sulphide Lubricant

40-page booklet on Moly-sulphide lubri-cant gives case histories for 154 different uses. Climax Molybdenum

1568. Nickel Alloys

32-page bulletin on use of nickel alloys n railroad equipment. International railroad equipment. Nickel

1569.Nondestructive Testing

Series of bulletins gives data on both ultrasonic and magnetic testing instruments. Illustrated. J. W. Dice Co.

Nondestructive Testing

8-page bulletin on equipment for non-destructive testing of bars, rods, tubing. Magnetic Analysis

Nondestructive Testing

Bulletin on latest ultrasonic testing equipment and techniques. Sperry Prod-

AUTO-LITE engineers say ...

REJECTIONS REDUCED 75% CRIMPING PROBLEM SOLVED

FREE-MACHINING, LEAD-BEARING
STEEL BAR



Auto-Lite is the largest independent manufacturer of automotive electrical equipment. This Auto-Lite stop light switch housing is made from La Salle LA-LED

• Because stop light switches affect driving safety, Auto-Lite tests each assembly for performance as a final operation. With B1113, cold crimping in the final assembly caused severe splitting and cracking, resulting in heavy assembly rejections. Since defective switches must be scrapped, this became expensive.

On housings made from LA-LED, rejections dropped from 4% to less than 1%. Because of faster machining, production also increased more than enough to offset the cost of using this premium grade steel.

Not only does LA-LED machine 45% faster than B1113 but it has other desirable qualities only an open-hearth steel can offer: better carburizing, a sounder cross-section than Bessemer steels, and good ductility. Furthermore, it machines to a fine satiny finish. Investigate the many advantages of LA-LED, today.

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NOVEMBER 1953; PAGE 31

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An announcement by the Industrial Gas Equipment Division, G.A.M.A.



'On April 15, 1953, members of the Industrial Gas Equipment Division of G.A.M.A. agreed on a program to assure you highest standards of safety, performance and durability in furnaces, ovens, boilers, melting equipment and other gas combustion assemblies

Obviously, it is impossible to develop laboratory tests and approvals, for protection purposes, as is the practice in other fields. Hence, each member has pledged himself to a Code of I thics governing claims he shall make for his equipment, as well as care to be used in its design and construction. Each signer agrees scrupulously to avoid false or misleading statements with respect to grade, quality, design, construction and performance

Your assurance that Code of Ethics principles underlie manufacture of the equipment you buy is the Signer's Seal, reproduced above. Look for it as the symbol of integrity

"Let us send you a complimentary copy of the Code of Ethics, and a list of signers with products they manufacture.

IC Schaeler

INDUSTRIAL GAS EQUIPMENT DIVISION G. A. M. A.

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ACCUMULATOR . CONTROLS . INDUSTRIAL GAS FURNACES PURIFYING MATERIALS . STEEL PLATE CONSTRUCTION . VALVES

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complimentary new booklet "Code of Ethics"

	pment Division, G.A.M.A. I, New York 17, N. Y.
Gentlemen Please s Ethics and list of si	end me a free copy of your "Code of gners.
Name	
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1572. Nonferrous Wire

Folder gives wire gage and footage chart and data on beryllium copper, phosphor bronze, nickel, silver, brass and aluminum wire. Little Falls Alloys

1573. Oil Quenching

Catalog V-1146 on self-contained oil cooling equipment. Selection tables for volume of oil required and oil recirculation rates. Bell & Gossett

1574. Openhearths

Brochure on modern openhearth design and construction. Loftus

1575. Ornamental Metal

Folder shows designs of perforated metals and lists applications. Accurate Perforating Co.

1576. Peening
Bulletin on use of cut wire shot for peening and cleaning. Park Chemical

1577. Phosphating

Pamphlet A-108 on phosphating materials. Phosphating reference chart included. Turco Products

1578. Pickling

80-page book "Efficient Pickling" covers all variables of process. Many charts and tables. American Chemical Paint

1579. Pickling Baskets

Data on baskets for degreasing, pickling, anodizing and plating. Jelliff

1580. Pickling Baskets

12-page bulletin on mechanical picklers, crates, baskets, chain and accessories, Youngstown Welding & Eng'g.

1581. Piercing

Slide calculator for determining the required pressure (in tons) for piercing a given size hole in any thickness and type of metal. Ward Machinery

1582. Pipe Standards
48-page booklet on codes and standards
for piping and pressure vessels. Taylor
Forge

1583. Plating Anodes

8-page catalog on sizes, shapes, composi-tions of copper, lead, zinc, tin, cadmium anodes, Federated Metals

1584. Plating Solutions

Bulletin 12 on electric heating of pick-ling and plating solutions. Pyrosil

1585. Powder Metallurgy

Information on sponge iron powder.

1586. Powdered Metals

Bulletin 3101 on compacting press for powdered metals, ceramics and plastics. Baldwin-Lima-Hamilton

1587. Precision Casting

Booklet on ferrous and nonferrous cast-ngs made by the lost-wax process.

1588. Presses

Bulletin No. 45 on recommendations for modernization and conversion of old presses. E. W. Bliss

1589. Protecting Aluminum
Folder on Alodine for protection of painted or unpainted aluminum. American Chemical Paint

1590. Pure Metals

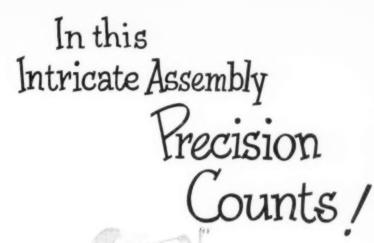
Data sheets on vacuum melted cobalt, copper, iron and nickel. Vacuum Metals

1591. Pyrometers

12-page Bulletin 713 on indicating and controlling pyrometers. Functional dia-grams of installations. General Electric

1592. Quenching

Bulletin 820 on automatic quenching





assures accurate and uniform components

In business machines, often very intricate assemblies of component parts, CMP THINSTEEL is helping to reduce end product cost. The efficient functioning of such equipment depends on the accuracy to size of many internal parts. The labor cost of assembling such parts may be the big item of cost. Once assembled, the machine must operate smoothly. The best insurance against machine failure is the use of the best raw material for component part manufacture. Experience shows that the best strip steel for accuracy and uniformity is CMP THINSTEEL. Try it for size.



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tanks for use with continuous heat treating equipment. Am. Gas Furnace

1593. Quenching

Data sheet on mixer for agitation of quenching liquids. Chemineer

1594. Radiography

16-page bulletin on materials and accessories for radiography. Density curves for four types of films. X-Ray Div., Eastman Kodak

1595. Recirculating Furnaces
16-page Bulletin 81 describes and illustrates heat treating furnaces for ferrous
and nonferrous parts and other heat treat
equipment. Despatch Oven

1596. Refractories

12-page brochure on products for casting special refractory shapes and for gunning and troweling applications, for services to 3000° F. Johns-Manville

1597. Refractories

20-page booklet gives technical informa-on on super refractories. Refractories Div., Carborundum Co.

1598. Refractory Cement

Bulletin discusses refractories and heat-resistant concrete. Lumnite Div.

1599. Rivets

12-page catalog on blind rivets. Applications, specifications, types, descriptions, Townsend Co.

1600. Roll Formed Shapes

24-page Bulletin 1053 on designing, forming and producing shapes from fer-rous and nonferrous metals. Roll Formed Products Co.

1601. Rustproofing

Folder on acid-proof coatings for metal finishing and chemical and metallurgical plant maintenance. Electro Chemical Engineering

1602. Safety Valves

Bulletin 400 on safety valves for shut-ting off fuel in case of power failure to essential unit. Western Products

1603. Salt Bath Control

Data sheet 5.2-5 describes instrumenta-tion for temperature control of salt baths in heat treatment of high speed steel. Minneapolis-Honeywell

1604. Salt Bath Furnaces

Data on salt bath furnaces for batch and conveyorized work. Upton

1605. Salt Baths

32-page bulletin on salts for tempering.

annealing, neutral hardening, martempering and carburizing. Heat treating data.

E. F. Houghton

Screw Thread Inserts

16-page book of design data and specifi-ations on screw thread bushings of cations on screw thread bushings of helically coiled wire, for aluminum, mag-nesium, iron. steel. Heli-Coil Corp.

1607. Selective Carburizer
Bulletin on "No-Carb" for selective
carburizing and prevention of decarburizing on high alloy steels during heating for
hardening. Park Chemical

1608. Shearing

16-page catalog on pivoted-blade shears for cutting metal up to 1.25 in thick. Cleveland Crane & Engineering

1609. Sheet Metal Testing

8-page folder on equipment for testing the drawing, stamping and folding quali-ties of sheet and strip. Deakin

Shell Molding

8-page technical bulletin on shell molding process for Alloy Foundry for stainless steel.

1611. Shot Peening

Selection and use of shot and grit for peening, Cleveland Metal Abrasive

Soldering Aluminum

6-page folder on use of a noncorrosive ux for soldering aluminum. Data on joint strength and ductility. Insulation and Wires, Inc.

1613. Soldering Aluminum

Article on techniques and materials for soldering aluminum. Reynolds Metals

Sonic Thickness Tester Measurement of wall thickness from one side by sonic method. Branson

1615. Specification Key

Guide to Government specifications for phosphatizing, rustproofing and paint bonding chemicals. American Chemical

1616. Specifications

Bulletin DM12n on magnesium specifi-cations of government agencies. AMS, SAE, ASTM. Dow Chemical

Specimen Grinders

6-page booklet describes grinders and surfacers for metallurgical samples, both belt and wheel types for wet or dry grinding. Buehler Ltd.

1618. Spot Welders

Folder on custom built precision : welding machines. Scientific Electric

1619. Spring Steel

18-page reprint compares three a spring steels. International Nickel C

1620.Springs

Data on compression, torsion, flat, tension, and special springs. Evans

1621. Stainless Fastenings

20-page catalog of stainless steel screws, nuts, washers, machine ser sheet metal screws, set screws, pipe ting and specialties. Star Stainless Sc

1622. Stainless Steels

20-page book on uses of stainless st Electro Metallurgical

1623. Stainless Tubing

Data Card 153 gives stress-rupture for nine grades of stainless. Babcoc

Stainless Tubing

8-page bulletin on corrosion-resistubing and fabricated piping. Youngst Welding & Engineering

1625. Stainless Tubing

28-page book on corrosion, uses fabrication of stainless steel tubing, and Tubes Div., Republic

Stamping Tester

Reprint on equipment for determine the drawability of sheet steel. Steel

1627. Standardization

24-page booklet defining standard production and their value as too management. American Standards A

1628. Steam Generators

20-page booklet on the six basic s generating units and allied equipr Union Iron Works

1629. Steel 52100

New stock list on 52100 tubing, bars ring forgings. Peterson Steels

1630. Steel Plate

32-page catalog 1243 on steel plat carburizing, heat treating and wel Many uses illustrated. W. J. Hollide

1631. Steel Tubing

48-page Handbook F-3 on fabric and forging steel tubing. Bending, ing, cutting and joining operations scribed. Ohio Seamless Tube

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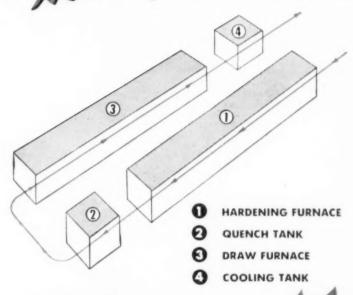
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Automatic Heat Treating Speeds Forging Production

Holcroft developed this automatic furnace unit in order to heat, quench and temper automotive crankshaft forgings.

It consists of a gas-fired hardening furnace, a quench tank, a draw furnace and a cooling tank. So automatic is the production, that a two-man team can handle the entire operation. As a result, the unit contributes materially to trimming production time to a third or even a half of that required by previous methods.

Now, it's entirely possible that this unit costs a little more to install. BUT-a close examination of the cost records indicate savings after savings after savings. Just simple arithmetic proves the economy of a "little more costly" Holcroft furnace. Write today for details. Holcroft & Company, 6545 Epworth Blvd., Detroit 10, Michigan.



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CANADA Walker Metal Products, 118 Windsor, Ontario

1632. Stereomicroscopes

20-page brochure on microscopes for three-dimensional magnification up to 45 diameters. Bausch & Lomb

Strain Gages

Article on fatigue life of SR-4 strain ages, in Testing Topics. Baldwin-Lima-Hamilton

1634. Surface Finish

Booklet on how to inspect and measure surface finish with a Vickers projection microscope. Ferner

Surface Treatment

Bulletin No. 51 on methods of treating metal surfaces with peroxygen com-pounds. Buffalo Electro-Chemical

Surface Pyrometer

Bulletin 168 on instrument for quick, ccurate readings of surface temperatures. Pyrometer Instrument

1637. Tanks and Linings

16 pages of data on tanks and corrosion-resistant linings for cleaning and plating solutions. Chemical Corp.

1638. Tap Selection

Slide chart gives drill size, lubricant and tap for each job. Treadwell Tap & Die

1639. Tellurium Copper

6-page pamphlet on properties of 0.5% tellurium copper alloy. Chase Brass

1640. Temperature Control Catalog of pyrometer supplies gives data on thermocouples, protection tubes,

other accessories. Arklay S. Richards 1641. Temperature Control

20-page catalog ND47 on controllers for temperatures up to 1000° F. Leeds &

Northrup

1642. Temperature Controls Bulletin F 5783 on Model 200 Series Capacitrols. Wheelco

Tempering

Bulletin 1E 11 on tempering and other applications in liquid baths. Kemp

1644. Tempilstiks

"Basic Guide to Ferrous Metallurgy", a plastic laminated wall chart in color. Claud S. Gordon

Testing Equipment

New 80-page illustrated catalog lists over 130 testing and measuring equip-ments for laboratory and production-line use. General Electric

1646. Testing Instruments

16-page bulletin on portable recorders, voltmeters and ammeters, surface roughness scales and other electric testers. Gen-

Testing Machines

28-page catalog on screw power uni-versal testing machines and accessories. Construction, specifications. Riehle

Textured Metal

Bulletin describes Armorphy, a compose of plywood and textured metal, U. S. ite of plywood Plywood Corp.

1649. Textured Stainless

Folder on stainless to conserve alloys and reduce weight. Rigidized Metals

1650. Thermocouples

20-page Bulletin 714 on thermocouples, protecting tubes and wells, insulators, leads, connectors, heads. Gen. Electric

1651. Titanium

30-page data book on properties of com-mercially pure and alloy titanium, melt-ing, forging and rolling. 16 charts and micros; 4 hardness conversion curves for titanium, Republic Steel

1652. Tong Ammeters

Bulletin on tong test ammeters, a.c. or d.c., for instant current measurements without breaking circuit or touching conductor. Columbia Electric

1653. Tool & Die Steels

28-page guide to qualities and sizes available. Uddeholm

Tool Heat Treating

Information on "Sure-Wear" process for eat treating high-speed cutting tools. LR Heat Treating Co.

Tool Steels

Full information on uses, compositions and heat treatment of carbon and carbon-vanadium tool steels. Vanadium-Alloys

1656. Tool Steel Color Guide

Color guide to estimate temperatures has heat colors on one side and temper colors on the other. Bethlehem Steel

Tool Steel Heat Treat

Bulletin 1147EE on electric furnace for eat treatment of high speed tool steel. heat treatn Hevi Duty

1658. Tool Steel Selector
Twist the dial of the 9-in. circular selec-

tor and read off the tool steel for your application. Crucible Steel

1659. Tube Straightening

Catalog describes two-roll rotary straightener for round tubes and bars 1/16 to 3/16 in. O.D. Medart Co.

1660. Tubing

12-page data book on brazed tubing made from copper-coated steel. Bundy

1661. Tubing

52-page "Handbook of Seamless Steel ibing." 26 pages of data. Timken Tubing.

1662. Ultrasonic Cleaning

Folder on principles and methods of metal cleaning by application of ultrasonic energy. Detrex

Vacuum Metallurgy

Bulletin gives résumé of vacuum metal-lurgical operations and research and de-velopment facilities and services available. National Research Corp.

1664. Weight Computer

Computer for weights of strips, sheets, bars, and plates of various metals and alloys. Also basic specifications for fabrication of pressure vessels. Continental Copper & Steel Industries

Weld Strength

Calculator indicates size of weld required for an applied load and weight of a given length of weld. Lukens Steel

1666. Welding Equipment

Catalog on Cadweld process and arc-welding accessories. Erico Products

Welding Torches

Booklet on Heliarc torches for inert gas shielded arc welding. Also data on electrode selection. nozzles and argon cylinders. Linde Air Products

1668. Wet Blasting Equipment

8-page folder on high velocity, pressure blasting. Cro-Plate

Wire Mesh Belts

140-page manual on conveyor design, belt specifications, metallurgical data. Cambridge Wire Cloth

X-Ray Unit

Bulletin 400-310 on self-contained X-ray unit for mass production inspection of parts. Westinghouse

1671. Zircon Ware

20-page bulletin on zircon refractory ware for laboratory use. Laboratory Equipment Corp.

November, 1953

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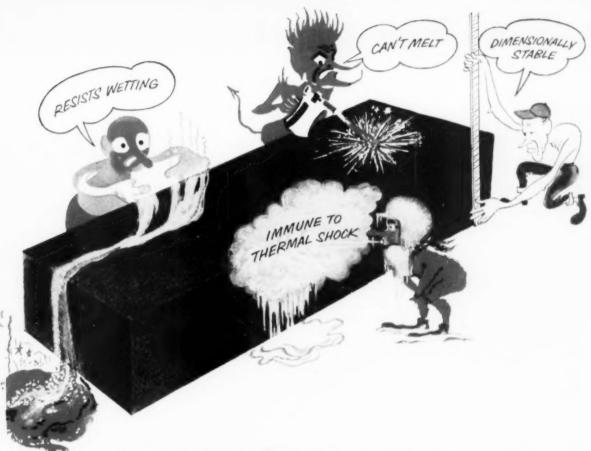
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13½" x 6" x 3" series 9" x 6" x 3" series 9" x 4½" x 2½" series



Write for Catalog Section S-6210

If you think of carbon only in terms of complete furnace linings, check these other important locations in and around the furnace where "National" carbon brick and shapes will also save time and money as a maintenance refractory:

- *√* RUNOUT TROUGHS
- / CINDER NOTCH LINERS
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how Tinnerman Products solved



a tough heat-treating problem:

• minimum

• minimum hardness was increased

• variation in hardness was reduced on AISI C-1064 STEEL

Tinnerman Products, Inc., Cleveland, Ohio, manufactures a large variety of spring clips and spring fasteners of the type pictured at the left. These parts range in thickness from .01 to .062 inches and are all made of AISI C-1064 spring steel.

Normal heat treating practice calls for heating to 1600 deg. F. in a controlled atmosphere. The parts are held at this temperature for approximately ½ minute, then are transferred by a shaker-type conveyor into the quenching bath, which is held at 120 to 125 deg. F. After quenching, the parts are tempered at 700 deg. F.

When Tinnerman used a conventional quenching oil, hardness varied from 50 to 60 RC—too low and too variable for suitable performance characteristics. Examination of the steel revealed that in all cases it was within specification limits,

After investigating a number of other quenching oils, Tinnerman Products discovered one that is outstanding—Gulf Super-Quench. Tinnerman Products is now quenching all of these parts in Super-Quench with remarkable results. Hardness is never lower than 60 RC and averages 62 ± 2. This improvement was obtained without any change in quenching temperature, degree of agitation, analysis, or grain size.

If you, too, are looking for ways and means to increase the efficiency of your quenching operation, it will pay you to investigate the advantages of Gulf Super-Quench. Write, wire, or phone your nearest Gulf office.

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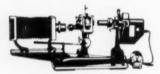
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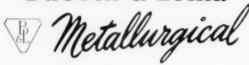


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Polaroid Land Camera Attachment

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... most complete line serving industry!

You can get better results, faster, in advanced research or in quality control, with the proper instrument or combination of equipment from the complete Bausch & Lomb line. Your Harshaw sales representative will be glad to show you how.

- Four different metallographs for routine bright field studies or advanced analyses requiring interchangeable phase contrast, bright field, dark field and polarized light.
- Photomacrographic Equipment Model L—widest low power range; no time lost in converting metallograph from high power set-up.
- CM Metallurgical Microscope—industry's standard.
- Stereomicroscopes unequalled for 3-dimensional low power studies.
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... Additives made possible

by the "DESEGATIZED" process

Lower Costs through Higher Production

Contact your local Latrobe representative for further information.

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MAGNESIUM FINDS INCREASING FAVOR AS DIE CASTING METAL

Advantages of light weight, easy machinability and competitive cost make Magnesium preferable for many types of die castings



Many manufacturers are taking a new look at magnesium as a die casting metal. In today's competitive markets, magnesium offers advantages that can't be overlooked.

Take light weight. Magnesium is the world's lightest structural metal. Where weight is a competitive factor, magnesium is the metal to use. A manufacturer of portable electronic dictation equipment found that nineteen eastings in zinc weighed 13 pounds, 6½ ounces; and in magnesium, 3 pounds, 10 ounces. That's real weight saying!

Magnesium is well known as the easiest of all metals to machine. This in itself promotes economy. As an example, the manufacturer of a lubricating machine found that the cost of machining an oil reservoir cast in grey iron was \$2.05 while machining the same part cast in magnesium cost only 80c,

Cost-wise, magnesium is better than competitive in numerous applications. One large automotive manufacturer (an industry where cost is figured on a fractional basis) has found magnesium die castings to be the lowest in cost of any metal in a score of applications. Moreover, magnesium's long-time record of price stability is also an important factor.

Now's a good time to take a close look at magnesium. For the competitive markets ahead, magnesium can offer you many advantages. Your nearest Dow office can give you up-to-the-minute information. Or write THE DOW CHEMICAL COMPANY, Magnesium Department, Midland, Michigan.

you can depend on DOW MAGNESHIM



How Armour ammonia cuts costs in sintering powdered metal parts



A. C. Gilbert uses a protective atmosphere of dissociated ammonia to sinter 102 parts for this American Flyer model train

Protective atmospheres of dissociated ammonia have proved efficient and economical for sintering powdered metals, as well as bright annealing, bright heat treating and other metal treating applications. Dissociated ammonia provides an easily controlled atmosphere at much lower cost than hydrogen. One cylinder of ammonia yields the equivalent of 34 cylinders of hydrogen—and is much less costly!

A. C. Gilbert has been using dissociated ammonia since 1951 to provide a protective atmosphere for sintering powdered metal parts of all kinds. They have had such success—in efficiency and economy—with powdered metallurgy and with dissociated ammonia that their equipment is running 24 hours a day, 6 days a week.

Gilbert is one of many satisfied customers using Armour ammonia. In many cases, Armour men have given help and advice on installations. That's just part of Armour's service to our ammonia customers. Since 1947, Armour has sponsored a fellowship at Massachusetts Institute of Technology for the study of metal treating processes using ammonia. The men of Armour's Technical Service Department are equipped to handle and answer any problem arising with ammonia installations for metal treating.

The booklets offered at right will show you how to put this know-how to work for you. Write today for your free copies. If your problems are unusual or pressing, write giving full details of your requirements,

> You can depend on Armour's Ammonia and Service



Standard Grades of Alloy Steel Will Often Do the Job

In many instances you can meet alloy steel requirements with standard grades. Applications, civilian or military, that really require the temperamental special grades are relatively few.

In the "special" bracket are the jobs where resistance to heat, corrosion, or low-temperature impact is the prime consideration. Here, generally speaking, you have to call upon other than standard grades. Bethlehem is usually able to supply them.

But wherever feasible, it is to your advantage to specify standard analyses—mainly for these reasons:

- Standard grades meet the usual requirements for hardness, strength, and ductility.
- 2. With standard grades, chemical ranges

usually fall within closer limits than those of special grades; hence you can use the conventional, more familiar—and often less costly—methods of heat-treating.

3. You can normally buy standard-grade steels in small tonnages, keeping your inventory low. In contrast, the user who orders an other than standard grade must in most instances specify a heat lot.

Bethlehem manufactures all AISI grades and special-analysis steels, and the full range of carbon steels. Please remember that we can always furnish the grade you wish, whether standard or special. But if there's any question of choice, anything not quite clear concerning grades and their applications, by all means discuss the problem with our metallurgists. They are always at your service.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. Export Distributor: Bethlehem Steel Export Corporation

BETHLEHEM

STEELS



Announcing

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Dew Point Controller

AND CONTROLS

Automatically



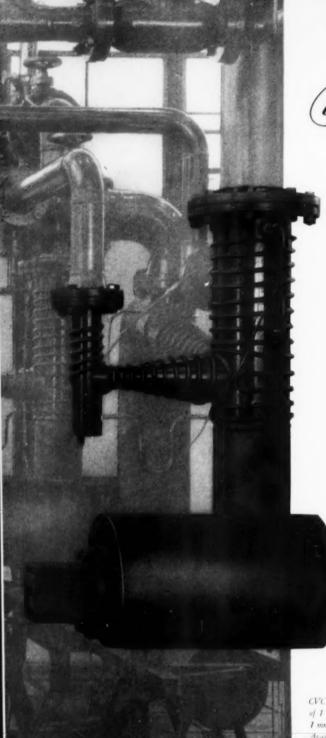
PATENTS PENDING

* AS FEATURED AT METAL SHOW

Exhibited for the first time at the October National Metal Exposition.
FOR COMPLETE INFORMATION, write today for free Bulletin No. 21-C.



IPSEN INDUSTRIES INC., 723 South Main Street, Rockford, Illinois Saircrast Saite to CARSONITRIDE - CARSONITRIDE - MASSER - SPATE - MARKEMPER - MASSER - MASSER



GVB Type KS Pumps

tailor-made for high vacuum metallurgy

Here's a small, compact unit that can bring large furnaces to high vacuum quickly and economically.

It's CVC's new KS-600, one of a series of two-stage booster-diffusion pumps. The first stage is an oil diffusion stage that produces a high ultimate vacuum. The second stage, with CVC's uniquely efficient oil ejector nozzle, pumps large volumes of gas into a high fore-pressure. Pumps of this type are available with different capacities to meet your particular needs.

Whether you're interested in a single pump, a complete high vacuum furnace, or any other high vacuum application, we will welcome an opportunity to discuss your needs with you. CVC's broad experience in high vacuum engineering coupled with unique design talents in metal processing equipment can help you solve your most difficult metallurgical problems.

Write for further information to Consolidated Vacuum Corporation, Rochester 3, N. Y. (A subsidiary of Consolidated Engineering Corporation, Pasadena, California.) Sales offices: Palo Alto, Calif. • Chicago, Ill. • Camden, N. J. • New York, N. Y.

CVC's KS-600 booster diffusion pump produces an ultimate vacuum of $I \times 10^{-5}$ mm Hg while operating into forepressures of more than I mm Hg. Maximum pumping speed is 2000 CFM at 10 microns. Available from stock.

Consolidated Vacuum Corporation

Rochester 3, N. Y.

high vacuum research and engineering



This Way

TO SOLVE YOUR HIGH-TEMPERATURE PROBLEM



Perhaps you no longer need to put up with the repeated troubles and expense that high temperatures can cause.

With this "Work Sheet" you can quickly give INCO's High Temperature

Engineering Service the direction to search out whether an INCO Nickel Alloy or another material is a practical way to solve your problem.







THE INTERNATIONAL NICKEL COMPANY, INC. 67 Wall Street, New York 5, N. Y.

Please send me the High-Temperature Work Sheet,

Company

•

Cit.

MP-II-53 NOVEMBER 1953; PAGE 43 Operator transfers evacuated retart from heating to cooling station of Stakes Vacuum Annealing Furnace, designed and built far the processing, annealing and other heat treatment of titanium, zirconium, hafnium, copper and other metals.









Installation of Stokes Rotary Vacuum Dryers used by Metals Disintegrating Co., Berkeley, California, for drying of aluminum powder. Highly oxidizable materials can be handled without any danger of

combustion or explosion when they are processed under vacuum.

Diesel locomative armature being removed, after impregnation, from Stokes high vacuum impregnating tank in the San Bernardino, Calif., plant of Atchison, Topeka & Santa Fe Railwey. Electric motors for the Santa Fe's "Chief" and "Super Chief" develop such excessive heat that ordinary insulation would swell or burst, causing the rotors to "freeze" in the mounting. By impregnating these rotors with protective resins under high vacuum in Stokes impregnators, each turn of wire is held in place, motors operate without interruption.

Vacuum at Work

Diesel locomotive motors, paper and metals, medicines, electrical parts, toys... are but a few in a wide range of products which are processed in vacuum for the good of mankind and the profit of business.

The application of vacuum engineering to industry is a major function with Stokes engineers. And naturally so, for it is at Stokes' that many of today's accepted procedures of vacuum processing had their inception during the last fifty years.

Stokes is First in Vacuum . . . first in the design and manufacture of practical vacuum processing equipment . . . and Stokes engineers are available for consultation on opportunities to apply vacuum processing to your business.

F. J. STOKES MACHINE COMPANY, PHILADELPHIA 20, PA.



HOW GRAPH-MO® HOLLOW-BAR CUTS COSTS OF RING-SHAPED TOOL STEEL PARTS

1. MACHINES 30% FASTER

Free graphite in Graph-Mo's® structure cuts machining time 30% over other tool steels. It has a minimum tendency to pick up, scuff, seize or gall. It's also the most stable tool steel ever made. A typical Graph-Mo steel master plug showed less than 10 millionths of an inch dimensional change in 12 years!

2. ELIMINATES DRILLING

With Graph-Mo Hollow-Bar, drilling is eliminated because the center hole's already there. Finish boring is the first step. You save machining time. Available in sizes up to 16" O.D. with a variety of wall thicknesses.

3. OUTWEARS OTHERS 3 TO 1

The combination of free graphite and diamond-hard carbides gives Graph-Mo unusual wear-resistance. Reports from users prove it outwears other tool steels an average of 3 to 1. And Graph-Mo responds uniformly to heat treatment.

4. MORE PARTS PER TON

You start closer to your finished product with Graph-Mo Hollow-Bar. You machine away a minimum of steel, cut scrap loss. Graph-Mo Hollow-Bar is distributed through A. Milne and Co. and Peninsular Steel Co. warehouses. For more information about Graph-Mo Hollow-Bar, write The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable address: "Timrosco."



SPECIALISTS IN FINE ALLOY STEELS, GRAPHITIC TOOL STEELS AND SEAMLESS TUBING

Facts about HELI-COIL inserts you should know

What they are

Heli-Coil* screw thread inserts are precision formed coils of stainless steel or phosphor bronze wire. Wound into tapped phosphor bronze wire. Wound into tapped holes, they form permanent, non-corrosive, strip-proof threads of astonishing strength. Available for National Coarse, National Fine and Unified threads, pipe threads and spark plug threads. They are made in all standard sizes and lengths for assemblies requiring Class 3, 3B, 2 or 2B fits.

What they are for

AS ORIGINAL COMPONENTS: Heli-Coil inserts are used to provide stronger, lighter fastenings, corrosion-proof, wear-proof threads in all assemblies.

FOR PRODUCTION SALVAGE: When conventional tapped holes are damaged in production, restore them on the line with Heli-Coil inserts. Get betterthan-original strength with no increase in screw size and no tell-tale signs of rework,

FOR SPEEDY REPAIRS: When tapped threads wear, strip or corrode in service, renew them in minutes on location in shop or field with *Heli-Coil* inserts. No welding—no plugging—no secondary machining—no oversize screws.

How they work

Holes are drilled and tapped as you do for ordinary threads-then Heli-Coil inserts are wound into tapped holes by hand or power tools. Install in a few second, as-sure thread protection forever. Can be used in any metal wood or plastic.

> No other method is so simple, effective and practical.

What they do for you

Heli-Coil inserts save money because they strengthen threads and make fewer smaller fastenings do the same holding job. They make lighter bosses and flanges practical and they sare weight in two ways: (1) By permitting use of cap screws, instead of bolts and nuts; (2) by allowing use of smaller, shorter, fewer cap screws. Helismaller, shorter, fewer cap screws. Heli-Coil inserts protect your product from thread wear, galling and stripping for life in every kind of metal, in plastics or wood. They preserve customer good-will by preventing product failure, due to thread fault. Heli-Coil inserts improve the end product, cut rejects, salvage threading errors.

Best time to put Heli-Coil inserts benefits to your use is right at the designing board, as many leading manufacturers are doing. But to convince you of their many advantages ask for a working demonstration right on your production line. Write to-day! Complete information and engineering data is available in the Heli-Coil catalog. Use Coupon!

*Reg. U.S. Pat. Off

Approved for All Military and Industrial Uses

How to save headaches in fastenings





Lend an ear to the many successes with tapped threads where stripping, wear, cross-threading and corrosion used to occur.



Open your eyes to the surest way to end thread problems forever-Heli-Coil* Screw Thread Inserts. This armored protection is simple to add -costs little-never fails.

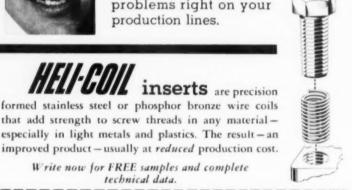


Tell us about your products and we will show you how to add lasting

protection against thread problems right on your production lines.

FII-COLL inserts are precision formed stainless steel or phosphor bronze wire coils that add strength to screw threads in any material-

improved product - usually at reduced production cost. Write now for FREE samples and complete technical data.



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HELI-COIL CORPORATION 271 SHELTER ROCK LANE, DANBURY, CONN.

Send Free samples and Handbook No. 652, a complete design

- manual.
- Send Free samples and put my name on list to receive "Heli-Call," case history periodcal

NAME _TITLE_ COMPANY ADDRESS

ZONE STATE





What's the <u>best</u> block insulation for 1900F?

SUPEREX ...

with the <u>proved</u> record

for long service!



The most widely used high temperature block insulation for over a quarter century...

SUPEREX® high temperature block insulation has long been industry's No. 1 choice for service temperatures up to 1900F. It provides major economies . . . reduces fuel costs, cuts heat losses, keeps maintenance expense down, costs less to install and has long service life.

These are the reasons why 90% of the nation's hot blast stoves are Superex insulated... and why the low cost open hearth steel producers use Superex in their regenerators.

Made of specially selected and calcined diatomaceous silica blended with other insulating materials and bonded with asbestos fiber, Superex will safely withstand temperatures up to 1900F with negligible shrinkage.

Superex has been used with outstanding success in all types of industrial and metallurgical furnaces and ovens, stationary and marine boilers, auxiliary power plant equipment, regenerators,

kilns, roasters, high temperature mains, flues and stacks.

Superex has all these important advantages...

Low thermal conductivity — Exceptionally high heat resistance (1900F) combined with excellent insulating value.

Light weight - Approximately 2 lb per sq ft per in thickness.

Great physical strength—Approximately 6 tons pressure per sq ft are required to compress Superex 14 in.

Long, efficient service life—Superex maintains high insulating value indefinitely will not disintegrate in the service for which it is recommended.

Fost, easy application—Superex may be cut with an ordinary knife or saw for fitting around openings or to irregular surfaces. Because of its light weight and convenient sizes. Superex assures fast and economical installations. For complete information about Superex block insulation, write for Brochure IN-134A. Address Johns-Manville, Box 60, New York 16, N. Y. In Canada, write 199 Bay Street, Toronto 1, Ontario.



Waste is minimized with Superex because of the variety of thicknesses available. Special shapes and intermediate



Johns-Manville



INSULATIONS



THE FURNACE OF PROVEN SPEED AND DEPENDABILITY IN THE SOLUTION **HEAT TREATING OF ALUMINUM!**

EIGHT SECONDS OR LESS is all the time required from heat chamber to complete quench with this DESPATCH high production aluminum heat treating furnace now operating in the aircraft division of a large automotive firm.

910° F. IN 25 MINUTES: A 426 KW heater has sufficient capacity to raise a 950° aluminum work load plus a 1000° steel rack to 910° F. in 25 minutes. Two high volume recirculating fans of 25,000 CFM each deliver heated air to the furnace, and heat uniformity is assured within a ± 5° F. Furnace is designed to operate up to 1250° F. when desired.

ELEVATORS AND WORK CHAMBER DOORS are hydraulically operated and interlocked with push button controls providing automatic sequence operation thru the complete cycle from heat treating to quench to unload. Furnace takes a work rack 4' wide, 5' high and 22' long.

EFFICIENT FOG QUENCH PREVENTS WARPAGE

An intermediate fog quench at floor level is provided before load is immersed in recessed tank. A series of fog jet nozzles are so arranged as to cover the load completely with a dense fog, a precaution against warpage of certain aluminum parts. The fog quench may be by passed if desired.

DESPATCH

Engineers, Fabricates and Installs a Complete Line of—

- *INDUSTRIAL FURNACES
- *INDUSTRIAL OVENS
- *HEATERS AND FANS
- *PAINT SPRAY BOOTHS *COMPLETE FINISHING SYSTEMS

PLAN FOR THE FUTURE WITH DESPATCH

DESPATCH ENGINEERS are designing it will pay you to keep DESPATCH in mind heat treating equipment today with tomorrow's higher production demands in mind. to your particular needs to give you the

When planning for the future in your plant most efficient operation at lowest costs.

Write, wire or call Dept. P

COMPANY

PIONEERS IN ENGINEERING HEAT APPLICATIONS FOR INDUSTRY



The Company faced with cold forming this thread rolled depressed head machine screw said, "We just wouldn't attempt to make it from any standard grade of 18-8!"



When this Company was asked to produce a second lot of these sheet metal screws from a regular 18-8, here was the reply: "Impossible—there's too much punch breakaget"

What would you do

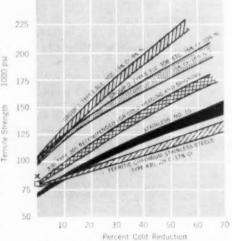
if you had to
mass produce
these fasteners
from 18-8 stainless
...without "losing your shirt"?

Both jobs were produced economically from a totally NEW chrome-nickel stainless!

Both companies successfully turned out these jobs with new Carpenter Stainless No. 10—the first chrome-nickel Stainless to permit economical, mass production of severely cold headed and upset fasteners and other parts. Carpenter No. 10 work-hardens far slower than any of the conventional 18-8 grades. That's the secret of its success. That is why it is ideal for cold headed bolts, screws, and upset nuts made on automatic machines. In fact, it is suited for any job involving heading, extrusion, severe coining and swaging. And the corrosion resistance of No. 10 is slightly better than Types 302, 304 and 305.

Of course, because of its high nickel content, Carpenter No. 10 is subject to present government regulations, and its supply is limited. Yet, we always like to keep you informed about the possibilities of a product like this. Upon request, we will be glad to give you more information about No. 10—its corrosion resistance, cold workability, machinability...as well as its usefulness for parts that must remain non-magnetic after severe cold working. So drop us a line on your Company letterhead, now...or any time. THE CARPENTER STEEL COMPANY, 133 W. BERN ST., READING, PA.

Export Department: The Carpenter Steel Co., Port Washington, N. Y -- "CARSTELLCO"



Comparison of various Stainless Steels showing increase of tensile strength with percentage of cold reduction.



Carpenter

Stainless No. 10

takes the problems out of production

Pioneering in Improved Tool, Alloy and Stainless Steels Through Continuing Research

Mow_ ALUMINUM SOLDERING MADE EASY!

A Universal Flux
for All Commercial Metals
Usually Joined
Soldering



SOLDERING FLUX

Here at last is the only flux ever developed that makes possible the <u>non-corrosive</u> joining of all types of aluminum alloys by any soldering method —manual, dip or mechanical. No cleaning is required after soldering is accomplished Aluma-Flux leaves no corrosive residue—soldered pieces are ready for use immediately.

S-X Aluma-Flux is equally effective for soldering stainless steel, bare and galvanized carbon steel, cast iron and other ferrous alloys, copper, brass and nickel—all commerical metals commonly joined by soldering. The joining of aluminum to brass; the coating of copper with tin; and the soldering of other unlike metals is made fast and easy with Aluma-Flux.

Soldered joints in aluminum produce no corrosive action due to flux residue when exposed to salt-spray, high humidity, alkaline water, etc. Aluma-Flux shows no detrimental effect on any soldered joint.

S-X Aluma-Flux can be used with 100% satisfactory results in powdered form as delivered, or in molten form—whichever is most efficient for the job. Virtually any type of solder can be used. Aluma-Flux can be stored indefinitely without change of weight, or any impairment of fluxing efficiency.

Being non-hygroscopic, it will not absorb water.

In addition to its exceptional fluxing characteristics,
Aluma-Flux offers many other cost-reducing,
time-saving advantages...

Menufactured By ESSEX WIRE CORP. Ft. Wayne, Ind.

The success of S-X Aluma-Flux in the soldering of aluminum is due to the action in which the flux initially reduces surface oxides and then immediately deposits a thin layer of plating material on the solder area. Oxidation of the area to be soldered is thus prevented while the plating material serves as an approved base on which to solder. In addition to its soldering efficiency, Aluma-Flux reacts completely during the joining operation so there are no corrosive flux residues to lower corrosion resistance of the finished

ALUMA-FLUX IS READY FOR IMMEDIATE SHIPMENT IN CONVENIENT SIZE METAL CONTAINERS.

Write Today For Complete Details

Distributed Only By

INSULATION and WIRES incorporated

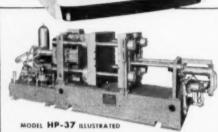
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1534A Swinney Avenue • Ft. Wayne 6, Indiana

KUX

FIRST NAME IN DIE CASTING MACHINES





Hydraulically operated die casting machine for production of aluminum castings.



Battery of KUX Die Casting Machines in operation in the ultra-modern Maytag factory at Newton, Iowa

-helps make

Maytag

first name in washers

Since 1907, over 6 million Maytag Washers have been sold—far more than any other. The reason's clear; Maytag makes a wonderful washing machine . . . plus a full line of other home laundry equipment and famous Dutch Oven Ranges. It's logical that KUX, first name in die casting machines, should be used in the quality production of these superior products.

The use of KUX die casting equipment can put YOUR PRODUCT ahead—or keep it ahead. Reduce your manufacturing costs—increase the saleability of your product, with quality die castings made on these rugged machines.

Write for illustrated catalog showing complete line of KUX Die Casting Machines

KUX MACHINE COMPANY 6725 N. Ridge • Chicago 26, Illinois



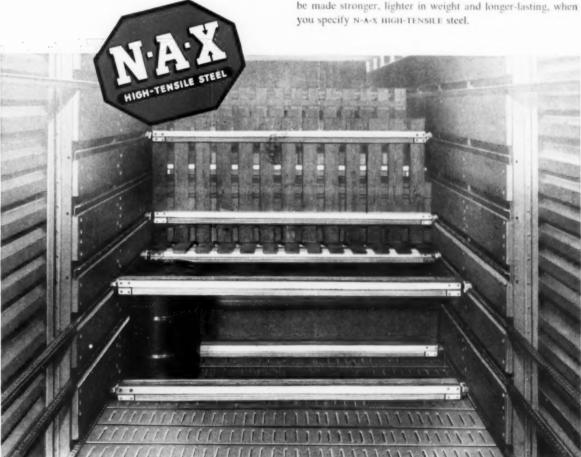
FIRST NAME IN DIE CASTING MACHINES SELECTED BY FIRST NAMES IN INDUSTRY

for Greater Strength with Lighter Weight

in modern material handling equipment The increasing use of the Evans DF Loader reflects the progress of railroads toward more efficient material handling methods.

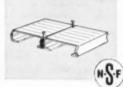
In the DF Loader there is high strength with minimum weight through the use of N-A-X HIGH-TENSILE steel. This lowalloy steel has 50% greater strength than mild carbon steel, with greater resistance to corrosion with either painted or unpainted surfaces.

You can get the same results as Evans. Your product can be made stronger, lighter in weight and longer-lasting, when



THE EVANS OF LOADER is a product of Evans Products Co., Plymouth, Mich. DF means Damage - Free, Dunnage - Free. NAILABLE STEEL FLOORING for boxcars, flatcars and gon-dolas is made of N-A-X HIGH-TENSILE steel, and is a prod-uct of Steel Floor Division, Great Lakes Steel Corporation.





Engineering data on these products available

The "Wonder Bar," a section of which is shown at left, is a vital part of the Evans DF Loader. It is a wooden bar reinforced by a Z-bar made of N-A-X HIGH-TENSILL.

The "Wonder Bar," when locked into place, secures all kinds of lading. It is strong enough to resist shifting load stresses in moving boxcars, yet so light that one man can lift it into position. The DF Loader provides real operating economies for both railroads and shippers.

Another modern product for efficient transportation equipment is Nailable Steel Flooring, also made of N-A-X HIGH-TENSILE steel.

GREAT LAKES STEEL CORPORATION

N-A X Alloy Division

Ecorse, Detroit 29, Mich.

NATIONAL STEEL

CORPORATION



AMPCO* METAL

... the special alloys that make good where other metals fail

HERE are some of the properties of Ampco Metal that help you keep production up, costs down:

- Unusual resistance to wear from abrasion, erosion, and cavitation pitting.
- Excellent resistance to corrosion in certain media.
- High tensile and compressive strength.
- High physicals at extreme temperatures.
- High strength-to-weight ratios.
- High impact and fatigue values.

Because it combines all of these qualities, Ampco Metal is often called **The** Metal Without an Equal.

No matter what you do — whether you run a steel mill, refine oil, make stampings, generate power, work in the chemical or process industries, or any of hundreds of other jobs, you can make Ampco Metal work for you. It saves operating headaches and production grief, because it often makes good where other metals fail.

These versatile special alloys fight wear, corrosion, impact, fatigue; give long life and dependable performance under the severest conditions. That's why they are widely used in such tough assignments as slippers and screw-down nuts for blooming mill service, fractionating towers, aircraft parts, dies, valves, bushings, and other punishing jobs.

Chances are Ampco Metal can help you, too. It's available in sand and centrifugal castings, sheets, plates, bars, tubes, extrusions, welding wire and electrodes. Consult your nearby Ampco field engineer or write us for full information.

*Reg. U. S. Pat. Off.



AMPCO METAL, INC.

Dept. MP11 • Milwaukee 46, Wisconsin West Coast Plant, Burbank, California

	learning more about the es of Ampco Metal. Please
Name	Title
Company	
Company Address	
City	() State



WITH AJAX-NORTHRUP INDUCTION

forgings FOR

Ajax-Northrup induction heat works so fast there's no time for scale to form. This not only saves steel, but gives longer die life, closer tolerances, a smoother finish and fewer rejects. This all adds up to steel saving—as much as 20% for some work.

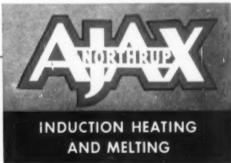
Ajax-Northrup heaters are available to heat all or any part of a billet, with precise temperature and gradient control, and with any desired type of automatic timing and handling devices. They fit right into your production line, take up little floor space, are clean, quiet, and easy to live with.

Our 37 years of induction heating experience can help you produce better forgings, cut costs, and save steel. Write us today.

Since 1916

AJAX ELECTROTHERMIC CORPORATION Ajax Park, Trenton 5, New Jersey

Associated Companies A LAX FLECTROMETALLURGICAL CORP. AJAX ELECTRIC FURNACE CORPORATION AJAX ELECTRIC COMPANY, INC. AJAX ENGINEERING CORPORATION



NOVEMBER 1953; PAGE 55

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56-Hour Work Week a Year

... Incoloy retort still going strong at temperatures up to 2050°

Here you see a long life Incoloy hydrogen annealing retort going into the furnace at L. & R.'s shop where it will soak at 2050° F. for 4 hours, then be gradually cooled to room temperature. It was fabricated by the Newark Metal Products Co., Kenilworth, N. J., from 1100 pounds of Incoloy.

Latest reports on Incoloy®, new companion alloy to Inconel®, include some remarkable service records.

As a hydrogen annealing retort, for instance.

Here—where other metals failed quickly, some in as little as 42 hours—Incoloy has already given over 3,000 hours of service. And it's still going strong.

This Incoloy annealing retort is being used by L. & R. HEAT TREATING COMPANY in Newark, N. J., for heat treating T.V. shields, hearing aid components, and laminators for servo-motors.

What an ordeal this retort goes through!

First, after being loaded, the retort is soaked at 2050°F, for 4 hours. Then the temperature is reduced 100°F, hourly until the retort reaches 1200°F. It is held there an hour and then allowed to cool to room temperature. A total heat of 11 hours. And it has to go through this grind four times a week!

L. & R.'s Incoloy retort has been in service a year now and it's still in shape for more of the same.

Their engineers, still watching Incoloy's record, already say service has been "very satisfactory."

The fabricators of the Incoloy retort, Newark Metal Products Co., Kenilworth, N. J., found that this new member of the Inco family was readily fabricated into heat treating equipment of all types. It is both workable and weldable for maximum flexibility in efficient design.

If you would like to learn more about Incoloy, write for your copy of "Preliminary Report on Incoloy."

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street New York 5, New York



Inco Nickel Alloys

Incoloy ... for Heat-Resisting Applications

ROLLICK FABRICATED SALLOYS



 Rolock "Serpentine" Trays carry Condenser Units on powered rollers thru furnace, for brazing at 2050°F.

BRAZING TRAY life increased 140% ... Maintenance decreased 100%

... at FEDDERS-QUIGAN CORP.

Rolock "Serpentine" furnace trays, built for this specific use, were furnished in two sizes... $24'' \times 30''$ (weight 22 lbs.) and $24'' \times 36''$ (26 lbs.). The maximum load carried by the larger tray is 80 lbs... in brazing, an exceptionally good ratio of load to weight. Some trays are of type 330 stainless, others are of Incoloy.

Trays formerly used had a maximum life of 2500 trips thru the furnace. Rolock trays give a minimum of 6000 trips...then are rebuilt for additional service.

Former trays required maintenance by one full-time skilled worker and a part-time helper; "Serpentine" have required absolutely no maintenance. Moreover, other trays frequently jammed in the furnace, causing costly down-time of the whole line. "Serpentine," no jamming, no down-time.

The answer, of course, is in the fully articulated "Serpentine" construction which resists warping to the highest degree. If this is one of your problems, write Rolock for practical solutions.

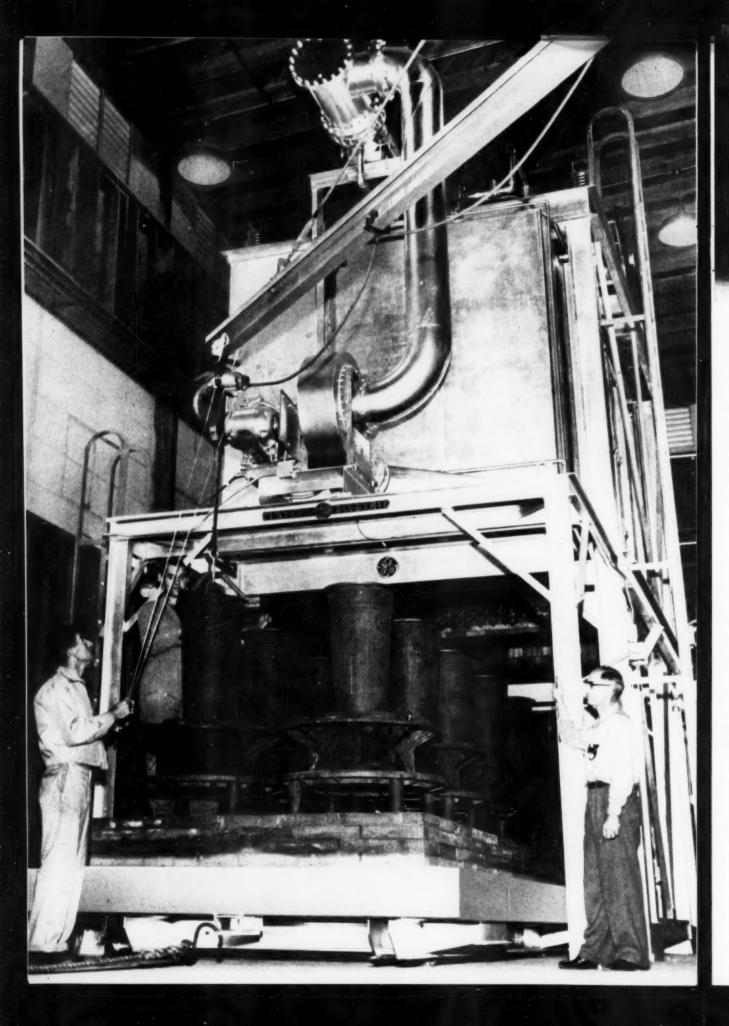
Send for Catalogs B-8 (Heat Treating) or B-9 (Corrosion Resistant)

Offices in: Philadelphia, Cleveland, Detroit, Houston, Chicago, St. Louis, Los angeles, Minneapolis, Pittsburgh

ROLOCK INC. . 1222 KINGS HIGHWAY, FAIRFIELD, CONN.

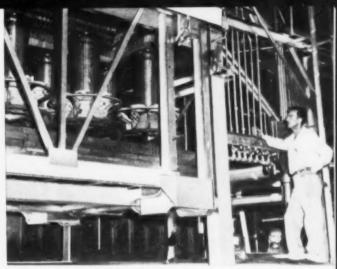
Back Content on for better work Easier Operation, Lower Cost

38653A





PROPER CONTROL AND TIMING of the complete heating cycle is provided by the G-E heating control unit above. To assure efficient furnace operation and uniform heating of parts, the unit provides automatic programming of heating and cooling cycles.



ONLY ONE OPERATOR is required to supervise temperatures, pressures, cooling phase, and atmospheric conditions. To minimize oxidation of jet parts a G-E gas converter, right, supplies gases of varying analyses as required by the heating cycle.

Solving Ryan's complex heating problem speeds nation's jet engine production

Key to success of America's jet engine program are the subcontractors who back up the large jet engine producers. One of these subcontractors is Ryan Aeronautical Co., San Diego, Cal. In setting up their jet aft frame production, Ryan had the problem of relieving residual stresses without distorting the metal.

After studying the problem with General Electric engineers, Ryan specified a furnace that would provide uniform heating and cooling at 200 F. per hour. Fast production at low cost was also necessary.

Applying years of experience gained in the development of America's first jet engine, G.E. designed and built a special elevator furnace that allows automatic program control of the complete time temperature cycle. This assures uniform heating of each part without weakening the metallurgical structure.

STRESS RELIEVING JET AFT FRAMES in this specially designed elevator furnace is accomplished with minimum distortion of metal. Constructed to assure low-cost, high-quality heat treatment the furnace is the result of years of G-E heating research. Fast cooling is provided by a special blower system that extracts hot air from the furnace, cools it, and then blows it back into the heating chamber. Elimination of costly reducing operations is made possible by using a G-E atmosphere converter to minimize oxidation of the aft frames. As a result Ryan receives consistently high-quality heat treatment.

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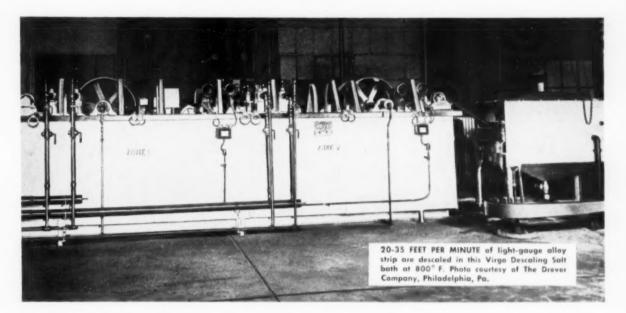
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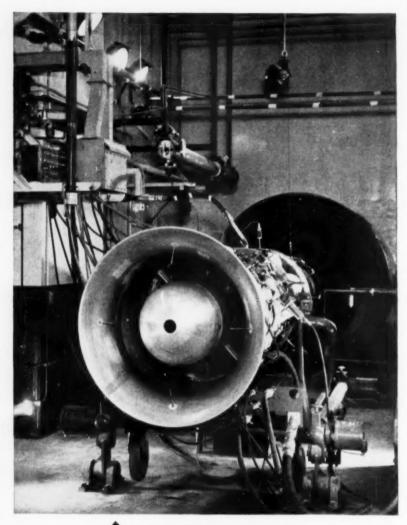
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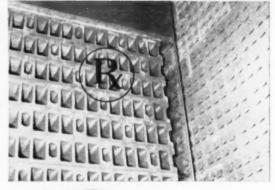
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- *DRIVE SHAFT—result of changing from B-1113 to Ledloy: production increased more than 35%, over-all costs decreased 20%.
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By DONALD S. CLARK
Professor of Mechanical Engineering
California Institute of Technology, Pasadena

order that one may understand the mechanism by which metals deform under dynamic conditions, the experiments must be made as simple and as direct as possible without the complication of added variables. After the metal behavior is understood, the effect of such factors as shape, dimensions and stress concentration may be studied more intelligently.

IMPACT AND STRAIN PROPAGATION

In 1804, Thomas Young stated that an elastic deformation of a bar is transmitted at a velocity corresponding to the velocity of sound in the

The Behavior of Metals Under Dynamic Loading

This discussion of the behavior of metals under dynamic loading will be limited to the manner in which metals respond to stresses imposed in a short period of time as compared with the relatively long time that is involved in what is commonly referred to as static loading.

It is not possible to establish exactly when a difference in the behavior of metals under static and dynamic loading was first recognized. By 1800 discussions of dynamic behavior began to appear in the literature. With the growth of railroads, the importance of the resistance of metals to dynamic loads became more apparent. During the past 150 years, engineers have been devising tests which might provide adequate comparisons to guide them in the selection of metals for installations subjected to dynamic loading.

During this period there has been much discussion on the meaning of these tests and ways to utilize the results in design. Most investigations have not provided information of a sufficiently fundamental nature to give an understanding of basic concepts concerning the behavior of metals under dynamic loading. In bar. For many years, it was not clear what would happen if the impact velocity were great enough to produce a strain in excess of the proportional limit of the metal. As a matter of fact, in the 1800's there was considerable uncertainty about the clastic limit and proportional limit. In 1941, von Karman and Taylor each independently established the theory of plastic strain propagation in metals by considering the equation of motion of particles in the metal in relation to the stress-strain diagram. According to this concept, the velocity of propagation will be less than that of an elastic strain and can be expressed by the relation

$$C_A = \sqrt{\frac{3a}{a}} \lambda r$$

 A Condensed presentation of the 1953 Edward DeMille Campbell Memorial Lecture presented before the annual meeting of the American Society for Metals in Cleveland, Oct. 21, 1953.

t A distinction between impact and rapid loading is important. In an impact type of loading, the inertia of the metal itself strongly influences the mode of deformation, while in rapid loading the load is applied more gradually, so that the inertia is not important.

Mathematics of Strain Propagation

where $\frac{\delta\sigma}{\delta\epsilon}$ is the slope of the engineering stress-strain relation at any given value of strain. Thus, the velocity of propagation, c, is a function of strain in the general case in which plastic as well as elastic strains are produced. The relation between impact velocity—the velocity at which the metal is set in motion at the point of loading—and the maximum strain produced is given by

Vi Cose

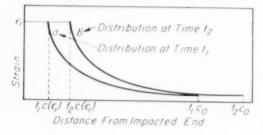
This relation indicates that an impact velocity, V_{1_2} will produce a maximum strain, ϵ_1 , which will propagate at a lower velocity than smaller strains. According to these formulas, the strain distribution in a very long bar struck by a mass traveling at velocity V_1 at two successive times, t_1 and t_2 , after impact, is given as curves a and b, respectively, in Fig. 1.

The validity of this analysis was proved by Duwez in 1942 by experiments on long annealed copper wires. The agreement between theoretical and experimental strain distributions was, if not perfect, quite satisfactory, as shown in Fig. 2. In making the calculations, it was assumed that static stress-strain relations prevailed during dynamic loading. Although it had not been quantitatively established in 1942 indirect evidence indicated that the stress-strain relation was higher under dynamic conditions than under static conditions. A higher stress-strain relation would account for the difference between the calculated and the experimental strain distribution.

DYNAMIC STRESS-STRAIN RELATIONS

The most fundamental indication of the resistance of a metal to deformation is a stressstrain relation. But how does one obtain a

Fig. 1—Strain Distribution in a Rod Produced by Impact. corepresents velocity of propagation of elastic waves, and c(w) represents velocity of propagation of plastic strain increment at a total strain of co



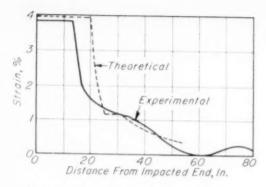


Fig. 2 - Comparison of Experimental and Theoretical Strain Distribution for Annealed Copper in Tension. Impact velocity 62.5 ft. per sec., duration of impact 1.3 millisec.

stress-strain relation during impact? Until recently, all attempts to obtain such relations have been disqualified because consideration was not given to the propagation phenomenon which prevails during impact. The tests have been made by measuring the force acting at one end of a specimen and the corresponding strain over some specified length of the specimen. In view of what has been said here about the propagation of strain, it should now be clear that the results of impact tests in which propagation effects are not taken into account will provide only average values and will not allow the establishment of the true relationship between stress and strain during the impact test.

Taylor and Wiffen made tests with small cylindrical specimens shot against heavy plates in which they took account of the inertia of the specimen in an approximate manner and found that the yield stress was increased above static values. Just this year J. D. Campbell conducted compression impact tests on long aluminum rods. Dynamic stress-strain relations for strains of the order of 0.006 in. per in. were obtained, the wave propagation phenomenon being taken into account in analyzing the results. The data drawn in Fig. 3 show a definite increase of the stress-strain curve by about 15 or 20% to higher values of stress for a given strain in the plastic region.

OTHER TENSION-IMPACT PROPERTIES

There are some significant dynamic properties of metals that may be obtained by means of the tensile impact test. For example, the maximum stress to which a metal may be subjected before failure occurs is greater under dynamic conditions than under static condi-

Static Vs. Dynamic Properties

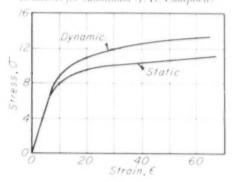
tions. This is illustrated in Table 1. In tests on cold rolled low-carbon steel, the ultimate strength is \$4,000 psi, statically and 105,000 psi, at impact velocities greater than about 25 ft. per sec. This is evidence of a higher stressstrain relation. Furthermore, most metals exhibit greater total elongation to failure under impact up to a certain impact velocity than under static loading, as illustrated in Table I.

A characteristic which may be of importance in some applications is the existence of a critical impact velocity of a metal. Referring to the expression given by von Karman relating impact velocity to the amplitude of the strain wave ri-

$$V_{i} = \int_{0}^{\infty} e^{it} dt$$

 $V_{\pm} = \int_0^{\tau_{\pm}} e^{\delta t}$ it is clear that there must be a maximum impact velocity corresponding to a tensile strain to at which the slope of the engineering stressstrain curve is zero; that is, the strain at the ultimate tensile strength. Thus, the velocity of

Fig. 3 - Static and Dynamic Stress-Strain Relations for Aluminum (J. D. Campbell)



propagation of an increment of strain at c is zero according to the relation

If an impact velocity greater than that corresponding to < is applied to a rod in tension. the large plastic strains cannot propagate as fast as the end of the rod is being pulled, and fracture of the rod will occur immediately at the moving end, no energy being absorbed by the rod. Actually, the necking associated with tensile failures of duetile metals, which is not taken into account in the theory of wave propagation, occurs very near the impact end. Very little strain is propagated beyond the neck and the total elongation and energy absorption of the rod drop below the values obtained at lower impact velocities, although the failure is not completely brittle. The velocity at which this behavior occurs is called the critical impact velocity. An example of the effect of impact velocity on the total elongation of an S.A.E. 1020 cold rolled steel rod is shown in Fig. 4 on the next page. The critical velocity of 100 ft, per sec. is clearly indicated,

Some experimental determinations of the critical velocity have been made on several metals and checked with the values calculated from the static stress-strain diagram. Some of these comparisons shown in Table I are good, but not precise; the correlation would be better if a raised dynamic stress-strain relation were assumed rather than the static relation.

Table 1-Static and Dynamic Tensile Properties

MATERIAL	ULTIMATE STRENGTH, PSL.		ELONGATION IN 8 IN.		CRITICAL VELOCIT	
	STATE	Dysamic	STATE	Dynamic*	Exp.	THEORET.
Ingot iron, annealed	37,100	57,400	25.7	16.2	100	1
S.A.E. 1015, annealed	50,600	63,500	28.0	30.0	100	
S.A.E. 1022, cold rolled	54,000	105,000	6.0	15.0	100	95
S.A.E. 1040, annealed	78,050	91.800	20.4	20.7	200	
S.A.E. 1045, quenched and tempered	142,900	169,000	5.7	9.2	190	88
S.A.E. 2345, quenched and tempered	145,250	175,250	5.1	14.1	> 200	161
S.A.E. 4140, quenched and tempered	134,250	151,000	8.5	14.7	175	132
S.A.E. 5150, quenched and tempered	139,000	148,100	8.5	13.3	170	159
Type 302 stainless steel	93,300	110,800	58.5	46.6	200	490
Copper, annealed	29,900	36,700	32.7	43.8	> 200	231
Copper, cold rolled	45,000	60,000	2.5	10.7	50	42
28 aluminum, annealed	11,600	15,400	23.0	30.0	5.200	176
2S aluminum, ½H	17,200		4.6	7.0	110	36
24S-T aluminum alloy	65,150		11.3	13.5	5.200	290
Magnesium alloy (Dow 1)	43,750	51,360	9.6	10.9	> 200	303

Maximum percentage elongation up to the critical velocity

Existence of a yield point prevents computation of critical velocity. Values are given in ft, per sec.

Time Delay in Yielding

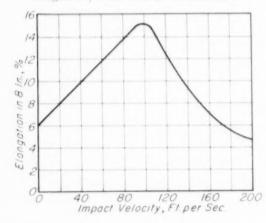
The proportional limit increases with increasing strain rate until it coincides with the ultimate strength of the metal, as shown in Fig. 5 for a low-carbon steel. The ultimate strength increases until a strain rate of about 200 in. per in. per sec. is reached.

DELAY OF PLASTIC STRAIN

In 1904 Hopkinson observed that iron and copper wires subjected to rapidly applied tensile stress could be stressed much beyond the static elastic limit and even beyond their static breaking loads and still remain in the elastic range, provided that the time during which the stress exceeds the clastic limit is of the order of 0.001 sec. or less. Hopkinson found that an annealed iron wire having a static upper vield stress of 40,000 psi, could withstand a stress exceeding 75,000 psi, for a period of about 0,001 sec, without any appreciable permanent deformation. This was a highly significant observation, but apparently was overlooked by most investigators concerned with the study of dynamic properties. Hopkinson's experiment with iron is possibly even more significant because he did not observe vielding in the specimen when it was dynamically loaded and released for a sufficiently short time.

A more complete study of the delay of yielding in low-carbon steel was made in 1949 at California Institute of Technology. In this investigation, rapid-loading equipment was devised by which a predetermined stress could be applied to a specimen in a time as short as about 6 millisec, and maintained constant for as long as desired. The time of 6 millisec, to

Fig. 4—Effect of Impact Velocity on Elongation of S.A.E. 1020 Steel, Cold Rolled



attain the desired load is large compared with the wave propagation times; therefore, propagation effects are not involved in studies with this equipment. Very careful determinations of stress and strain relations were made under static conditions to establish the static upper vield point of a low-carbon steel. Tests were then made in the rapid-loading equipment by impressing stresses in excess of the static upper yield point. It was observed that stresses above but near the static upper yield point could be maintained for a reasonably long time before the specimen vielded. The interval during which the stress was maintained constant before yielding has been called the delay time. By increasing the stress, the delay time before vielding decreased as shown in Fig. 6,

The lower limiting stresses represented by the horizontal portion of the curves for the

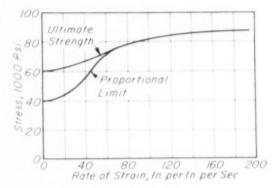


Fig. 5 – Effect of Strain Rate on the Proportional Limit and Ultimate Strength of a 0.22% Carbon Steel

higher temperatures coincide with the upper yield stress as determined by tests in which the load was applied very slowly. Delay time increases with decreasing temperature for a given stress. One would expect this behavior to be related to a thermal activation process, but so far such a relationship has not been established. Tests made at a temperature of -320° F. by Wood indicate that there is an upper limiting stress at which the delay time rapidly tends toward zero with increasing stress. In lowcarbon steel, this limiting stress is of the order of 126,000 psi. Some of the specimens that were tested at this low temperature failed in a completely brittle manner. One might suspect that there is some relation between the maximum limiting stress and brittle fracture. However, completely brittle fractures were not exhibited by all specimens tested at the limiting

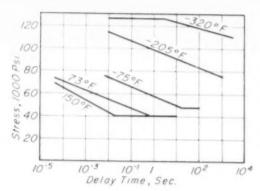


Fig. 6 – Delay Time for the Initiation of Yielding at Rapidly Applied Stresses in 0.175 Carbon Steel at Room Temperature

stress, and some of the specimens tested at slightly lower stresses did fail in a brittle manner.

This discussion has been concerned with delay phenomena in a metal which exhibits a distinct yield point. What about the behavior of a metal for which the static stress-strain curve does not possess a discontinuity? Rapidload tests have been made on such metals, including 18-8 stainless steel, normalized A.I.S.I. 4130 steel, quenched and tempered A.I.S.I. 4130 steel, 24 S-T aluminum alloy and 75 S-T aluminum alloy. The tests on these metals showed that plastic deformation occurs during the loading period and that a distinct delay time for yielding does not exist.

However, in the tests made on stainless steel subjected to a rapidly applied constant stress, the rates of strain are such that an appreciable time is required for the plastic strain to reach its equilibrium value as given by the static stress-strain curve. In a static test, a stress of about 42,000 psi, is required to pro-

duce a deformation of 0.4%. In a test in which the stress is rapidly raised to this same value and held constant, a strain of 0.4% is not attained until a time somewhat greater than 1 sec. has elapsed. This time effect was rather small in the other metals tested.

PREYIELD MICROSTRAIN

Vreeland recently studied the microstrain which occurred during the period of delay before yielding. The variation of this microstrain

Effect of Carbon and Nitrogen

with time is shown in Fig. 7 for different constant stresses. The rate of strain is greatest at the beginning of constant load and decreases until a microstrain of about 30 x 10° in, per in, at stresses greater than approximately 40,000 psi, is present. After the strain has reached this order of magnitude, yielding occurs. Similar amounts of preyield microstrain have been observed by Roberts, Carruthers, and Averbach. This strain is of considerable importance in establishing a probable mechanism of the delay phenomenon which will be discussed further on.

Before the probable mechanism of time delay in yielding is discussed, the results of some other investigations that are pertinent to this study should be examined. The work of Low and Gensamer, Holden and Hollomon, and Schwartzbart and Low has shown that the presence of a yield point in the stress-strain diagram of iron or low-carbon steel is attributable to the presence of carbon and nitrogen. Some investigators have shown that the yield point is eliminated by the removal of practically all carbon and nitrogen.

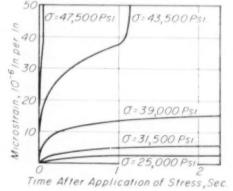
Specimens treated in wet hydrogen to decrease the carbon and nitrogen content were subjected to rapid-load tests to determine the existence of any delay phenomenon. While the static stress-strain diagram did not exhibit a distinct yield point, the rapid-load tests did show a delay time and a distinct yielding. This behavior may be ascribed to the presence of a very small residual amount of carbon and nitrogen in the steel.

Recovery by Aging — An interesting series of tests was made to determine if the rapid loading of a low-carbon steel at a stress above the static upper yield point.

for a period of less than the delay time at that stress, will have any effect on the time required for initiating yielding on a second application of the same stress.

The tests were made by rapidly loading a specimen of low-carbon steel to a stress in excess of the static yield point. This stress was maintained for a period approximately three-fifths of the normal delay time, so that yielding did not occur. The same specimen was again loaded rapidly to the same stress and the delay

Fig. 7 – Microstrain Vs. Time at Different Rapidly Applied Constant Stresses for a 0.12% Carbon Steel



Theory of Yield

time measured. In all cases, the specimens yielded on the second application of load in a time which made the total time at stress about equal to the delay time that would be required with only one application of load. Other tests were made in which the specimens were aged for different times at different temperatures during the period between stress applications.

Results are shown in Fig. 9. Specimens that were aged for at least 100 min, at a temperature of 150 F. after each loading could be subjected successively to the rapidly applied stress without yielding, provided the time at load for each application was approximately three-fifths of the normal delay time. Aging at a temperature of 200 F, for at least 12 min. accomplished the same result. In other words, aging for the proper length of time at these temperatures apparently erased the effect of prior applications of stresses in excess of the static yield point. This means that some readjustment occurred in the structure during the aging treatment. From the two pairs of values of critical time and temperature of aging which were found to eliminate the effect of a previous stress pulse, an activation energy for the process of about 19 kg-cal, per mole was determined, which is just the activation energy for thermal diffusion of carbon and nitrogen in iron, within the accuracy of the data. Thus, the recovery of the material from the effects of short duration stress pulses represents auother aspect of the yield phenomenon which is intimately related to the presence of carbon or nitrogen in the steel.

MECHANISM OF DELAY TIME

A theoretical explanation of the yield point in low-carbon steel in terms of dislocations and their interactions with interstitial atoms of carbon and nitrogen has been in process of development over the past several years. The phenomenon of delayed yielding, the microstrain which precedes yielding, and the recovery by low-temperature aging from the effects of stress pulses may be correlated with the theoretical developments – at least qualita-

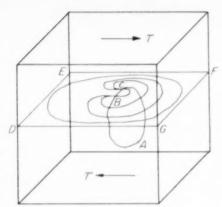


Fig. 8 Frank-Read Dislocation Source

tively. The theory depends upon three concepts.

The first, due to Cottrell, is that foreign atoms in solid solution form "atmospheres" around dislocations, and that such atmospheres tend to anchor the dislocations so that they are more difficult to move. A detailed theory of the manner in which dislocations may be released from atmospheres of foreign atoms under the combined action of an applied stress and thermal fluctuations

has been presented by Cottrell and Bilby, who show that the thermal activation energy required for the release of a dislocation from an atmosphere decreases as the stress is increased. Thus, according to this theory, anchored dislocations will not begin to move immediately when a stress is applied but must wait for thermal fluctuations of sufficient magnitude before they can be released from their atmospheres of foreign atoms. It is clear that the mean time for such release decreases with increasing stress and with increasing temperature. It should be pointed out here for reasons which will become apparent later that the stress which is of importance is the local resolved shear stress in the slip plane and in the slip direction. This local stress may contain a contribution from other neighboring dislocations as well as the stress due to an externally applied load.

The second concept of importance to the present theory of the yield point in polycrystalline iron and low-carbon steel is that grain boundaries constitute relatively strong obstacles to the motion of dislocations previously released from anchoring atmospheres. That is, a considerably higher local stress is required to release a dislocation from a grain boundary or to cause a free dislocation to pass through a boundary than is required to release an isolated dislocation from an anchoring atmosphere. This concept was first put forward by Cottrell in 1950.

According to this view of the theory, when a load is applied to a specimen of annealed low-carbon steel, dislocations which are released from carbon and nitrogen atmospheres within the grains move freely to positions near the grain boundaries and are stopped there. As time goes on with the external load maintained, more and more dislocations are released

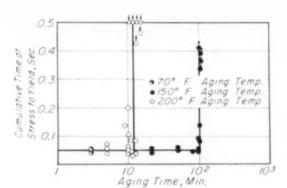


Fig. 9 – Effect of Aging Temperature and Time on the Time to Initiate Yielding at Constant Stress for a 0.12% Carbon Steel

within the grains and pile up against the boundaries. If at some point near a grain boundary enough dislocations accumulate, the resulting high local stress at the boundary reaches a critical value at which dislocations may be released from or pass through the grain boundary. This point in the process represents the initiation of macroscopic yielding.

The third concept of importance for the present dislocation mechanism of the yield point is the Frank-Read dislocation multiplication mechanism. This is a specific mechanism for the generation of many dislocations, all lying in a single slip plane, as shown in Fig. 8. A segment BC of a dislocation loop ABC lies in the active slip plane DEFG. The end points B and C of the segment are effectively fixed. When a shear stress of proper magnitude is applied, the segment BC will curve and generate new dislocation loops as indicated. When a new dislocation loop is formed, the original segment BC is re-formed.

A combination of these three concepts provides a dislocation model of an individual yield nucleus in annealed low-carbon steel. This model consists of a Frank-Read dislocation source with a saturated Cottrell atmosphere of carbon or nitrogen atoms or both which lies in a slip plane at some distance from a grain boundary or other obstacle to dislocation motion, such as a patch of cementite. The distance from the source to the obstacle is considered to be large, compared with the length of the Frank-Read source.

The behavior of such a yield nucleus under the influence of a rapidly applied constant resolved shear stress due to externally applied loads may be described qualitatively as follows: New dislocation loops are generated at the

The Dislocation Mechanism

Frank-Bead source and move rapidly out in the slip plane until they come to rest at positions in which they are in equilibrium under the combined action of the externally applied stress, the stress due to the obstacle, and the stresses produced by dislocation loops previously generated by the same source. As the number of dislocation loops accumulated in this way increases, the local stress at the Obstacle increases, and the local stress at the Frank-Read source decreases. This effect follows from the nature of the stress fields of dislocation. Since the rate of generation of new dislocation loops is an increasing function of the local stress at the

Frank-Read source, this rate decreases with time, following the application of the externally applied stress. If the applied stress is below the static upper yield stress, so that the obstacle does not break down as the dislocations accumulate, the generation of new dislocations eventually stops. However, if the stress is above the static upper yield stress, a sufficient number of dislocations will be formed to break through the obstruction, resulting in yielding.

Vreeland's prevield inclastic microstrains may be identified with the generation and motion of dislocations which accumulate in the yield nuclei prior to the onset of macroscopic yielding. It is evident from Fig. 7 that these prevield microstrains occur in a manner which is in good qualitative agreement with the dislocation model. The behavior of a material containing vield nuclei of the type postulated is also consistent with the measurements of the delay time for yielding and its dependence upon applied stress and temperature, as shown in Fig. 6. Finally, the mechanism explains the behavior of the material where it is subjected to short duration stress pulses above the static upper yield stress, and the recovery from the effects of such stress pulses by appropriate timetemperature aging treatments. The latter effect is due to the diffusion of carbon or nitrogen atoms, or both, to the dislocations generated during the previous stress pulse and the resulting stabilization of the array of dislocations.

The quantitative details of these theories are far more complicated than has been indicated here, but this discussion should be sufficient to indicate the progress that has been made in trying to explain certain phases of the dynamic behavior of metals. Eventually these theories will provide a working basis for the practicing design engineer.

Effect of Iron on Hardness, Bend Properties and Welding of Titanium Sheet

THE THANIUM sponge production process used by Du Pont yields metal containing small amounts of contaminants. The two more important are oxygen and nitrogen, which have been brought under improved control by basic engineering advances.

Another important residual element is iron, derived from the steel vessels used in the reduction of titanium tetrachloride with magnesium. While most of the titanium averages less than 0.25% iron, some with up to 0.5% is produced. Economies demands that this material be utilized.

It appears that iron, which stabilizes the beta phase, can be tolerated in two alloy categories, namely the alpha-beta and the beta alloys. Its effect upon alpha alloys has not been clearly By W. J. BARTH, Metallurgical Engineer and A. L. FEILD, JR., Metallurgist E. I. Du Pont de Nemours & Co., Inc. Pigments Dept., Chemical Div. Newport, Del.

established. Most of the wrought titanium sold to date, however, has been an oxygen-nitrogencarbon alpha alloy containing up to 0.25% iron and having a nominal yield strength of 70,000 psi. This alloy has been designated by the various producers as RC-70 (Rem-Cru Titanium. Inc.), RS-70 (Republic Steel Corp.), Ti-100-A (Titanium Metal Corp.), and MST Grade III (Mallory-Sharon Titanium Corp.). We know of no instance wherein this alloy has been rejected

Table I - Composition and Constitution of Titanium Ingots

Desig-	N	C	FE		0		Міско-	
NATION#			ACTUAL	INTENDED	ACTUAL	INTENDED	STRUCTURE	
A-0.20	0.025	0.03	0.20				US · Mo-mo	
A-0.44	0.02	0.03	0.44	0.50			US = Mo-me	
A-0.90	0.02	0.03	0.90	1.00			US · Mo-m	
B-0.53	0.03	0.035	0.53				US Mo-me	
B-0.94	0.027	0.03	0.94	1.00			US+M1-m	
C-0.22	0.063	(),()-}	0.22				US - Mo-me	
C-0.54	0.075	0.03	0.54	0.50			US Mo-me	
C-1.02	0.082	0.04	1.02	1.00			U8 M1-m.	
D-0.4-0.0	0.025	0.025	0.37				US · Mo-me	
D-0.4-0.15	0.03	0.035	0.40		0.15	0.10	US - Mo-mo	
D-0.4-0.24	0.03	0.03	0.39		0.24	0.20	US Mo-m	

*Letter indicates batch of sponge; first figure represents iron content; second figure (batch D) represents oxygen content.

IUS uniform A.S.T.M. grain size 8.

 $\begin{array}{ll} \textbf{\textit{M}} = \text{macrosegregation } \\ \textbf{\textit{m}} = \text{microsegregation} \\ \end{array} \\ \begin{array}{ll} 0 = \text{none; } 1 = \text{light: } 2 = \text{medium.} \\ \end{array}$

Table II - Bend Tests in Terms of T★

DESIG- NATION	LONGI- TUDINAL	TRANS- VERSE	WELD
A-0.200	1	1	114
A-0.44	114	114	112
A-0.90	2	2	2
B-0.53	112	112	112
B-0.94	2	2	2
C-0.22	2	2	2
C-0.54	2	2	3
C-1.02	$3^{1}2$	4	3
D-0.4-0.0	112	112	2
D-0.4-0.15	2	212	2
D-0.4-0.24	3	312	3

*Samples are bent in V-die with 75° angle (see Fig. 2 on p. 76).

T radius of bending die. Test is more severe as value of T decreases.

because of variable iron content, although some commercial shipments have averaged 0.3 to 0.4% iron.

In view of all these facts we initiated a research program on the effects of iron in the range of 0.25% to 0.5% on some common mechanical properties of titanium.

Four sponge batches were used for this investigation, and iron and oxygen additions were made synthetically. Compositions are shown in Table I. To facilitate tabulation, the sponge batches are ranged from A to D in order of increasing hardness. Batch D has high iron and was strengthened by oxygen addition, Batch C represents a high hardness batch modi-

fied with iron. Approximately equivalent mechanical properties were obtained for equivalent yield strength levels, which in turn cover the range for alpha alloys of commercial purity.

Hardness is plotted against iron content in Fig. 1, left. (Vickers hardness with 10-kg. load was taken perpendicular to the longitudinal cross section. micropolished.) Hardness change from 0.25% to 0.50% Fe is not very great, although there is an appreciable rise from 0.5% to 1% Fe. Reasons for this behavior are

Mechanical Property Relationships

unknown. It will be noted that the slope of the lines from 0.5 to 1.0% Fe is independent of the hardness level of the original sponge. All of the alloys investigated exceed the solubility of iron in alpha titanium, and excess iron as beta spheroids was found by metallographic examination (see Fig. 3, 4 and 5).

Rolling and annealing cycles were held approximately constant, to simulate commercial rolling practice and to perform the hot work in a constant region of the alpha-beta field of the Ti-Fe phase diagram.

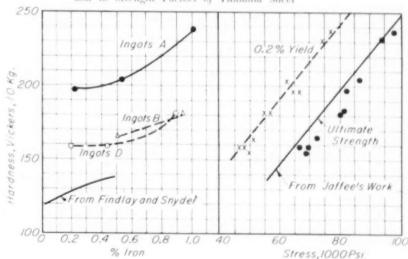
Data previously reported by Finlay and Snyder in *Journal of Metals*, for February, 1950 are included in Fig. 1 to show the slow change in hardness with iron content of iodide titanium.

Tensile properties also correlate with hardness as shown in Fig. 1 at right. The correlation obtained is closely associated with the straight line for ultimate strength established by Jaffee, Ogden and Maykuth (Journal of Metals, October, 1950).

The strength shows a marked increase as the iron goes up from 0.50 to 1.07, while the elongations indicate that the ductility of the laboratory-produced material is equivalent to commercially produced sheet.

Commercial bend specifications as related to yield strength are generally met up to 1% iron. As shown in Table II, iron at the 0.5% level has no apparent effect on sheet directionality and weld bend quality. A representative series of bends is shown in Fig. 2.

Fig. 1 - Relation of Hardness to Iron Content and to Strength Factors of Titanium Sheet



Iron in Titanium

Structure—The microstructures are illustrated in Fig. 3, 4 and 5. All the material was fine grained, having an equi-axed alpha structure with dispersed beta spheroids. As is seen in Table 1 on p. 74, pronounced segregation was observed only in the sample designated C-1.02 containing 1% iron.

Figures 4 and 5 indicate that the ½% and 1% iron alloys may be considered as alpha-beta alloys. There is a major difference, however, between these and one such as the 8% Mn alloy designated RC-130-A and RS-120. The latter, in hot rolled condition, consists of alpha islands in a beta matrix, whereas our ½ and 1% iron alloys consist of beta islands in an alpha matrix. Presumably, then, the low-iron alloys would behave essentially as alpha alloys and would exhibit superior high-temperature strength and creep properties.

Aging—During this investigation some weld bead hardening from air cooling was observed in the welds made for bending tests. This had already been reported in the literature. Hardening indicates an unstable condition and a possibility of embrittlement by aging at service temperatures. While the former work did not show any marked aging of metal containing less than 17 iron, we made some tests on 0.57 iron sheet to clear up this point.

Welded samples were aged, since the welding of 1/16-in, sheet represents the most drastic heat treatment encountered during the fabrication of titanium. There was no change in weld ductility as measured by the bend test after aging from 2 to 32 hr. at 400° C. (725° F.) and 230° C. (446° F.). These periods were used since the other investigations had shown age hardening for similar intervals in quenched beta titanium, higher in iron. We also found no change in the weld hardness after aging.

EXPERIMENTAL PROCEDURE

It may be of interest to describe briefly our experimental procedure:

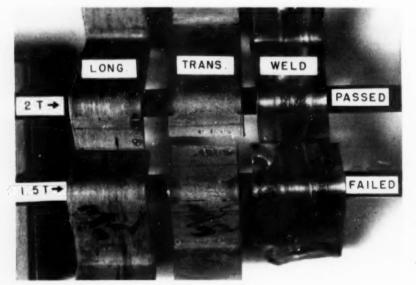
Two-pound are-melted ingots were prepared. These ingots contained from 0.20% to 1.00% iron as shown in Table I, any iron additions being made directly to the charge in the form of a titanium-iron master alloy prepared from National Bureau of Standards' 55C iron powder. The ingots were subsequently sectioned to produce rectangular slabs (2%x2%x1 in.) for rolling. Hot reduction, starting at 1425 F, in 10 to 12 passes in rapid succession, with no cross-rolling, on a 10-in, two-high mill, resulted

in 16-gage (0.060-in.) sheet for test purposes. These sheets were air annealed at 1425° F, for 20 min, and air cooled. Test coupons were obtained from all parts of the sheets. Weld and hardness samples were descaled by belt grinding. Sheet bend and tensile samples were tested without descaling.

The sheet produced was from 30 to 35 in, long by 25 in, wide, Longitudinal micro samples were taken from each end and the center. Segregation was rather uniform along the length (Table 1).

Vickers hardness was determined at three locations and found to be uniform, indicating good distribution of alloying elements. Ingots A had maximum variation of 2 Vickers numbers.

Fig. 2—Representative 7.5° Bend Tests on 1–16-In, Sheet From Ingot A-0.90, Showing Uniformity of Longitudinal, Transverse, and As-Welded Bends. Longitudinal and transverse samples have surfaces as rolled. Longitudinal properties of this sheet are: 0.27 yield strength, 55,000 psi.; ultimate tensile strength, 80,000 psi.; elongation in 2 in., 25%; hardness of sheet surface, Bockwell G-66; hardness of sheet cross section, 182 Vickers 10-kg



end to center to end; ingots B. 6 numbers, ingots C. 5 numbers, and ingots D. 8 numbers—the hardest ones with the highest amount of impurities generally having the largest variation. We noted that the samples with largest hardness spread had the most segregation, as reported in Table 1.

Grain size was essentially uniform throughout in all sheets.

The experimental weld beads were deposited in a small inert-atmosphere are furnace. Weld conditions were: are travel 6 to 8 in. per min., 40 to 50 amp., 20 to 30 volts, d-c, straight polarity and a 3/32-in, electrode. To determine the reliability of the furnace two weld beads were remelted; hardness and bending tests were substantially unchanged, even after the second remelt. Consequently, air contamination in the furnace was virtually nonexistent and the weld bead hardening therefore resulted from quenching.

CONCLUSIONS

Based upon the data developed, we conclude that 0.57 iron has little effect on the room-temperature mechanical properties of commercial-purity alpha alloys such as RC-70, RS-70, Ti-100-A and MST Grade III, in the range of 55,000 to 70,000-psi, yield strength. Data have been presented which demonstrate that laboratory-produced sheet of variable iron content generally complies with commercial sheet specifications. Very little directionality was observed in the sheet bend test, and weld bend and sheet bend values are equivalent.

Iron contents were investigated up to 1% to obtain practical limitations. The addition of 1% iron had a pronounced strengthening effect, although sheet and weld bend quality remained generally satisfactory.

Aging studies on commercial purity alloys containing 0.5% iron showed stability, as-welded, at service temperatures ranging up to 400° C. (752° F₃).

No high-temperature data such as creep or stress-rupture were obtained. Published work by other investigators indicates that the effect of an additional 0.25% to normal iron contents (or a total of 0.5%) would have negligible effect on the creep characteristics.

Equi-Axed. Wrought Alpha Grains With Dispersed Beta Spheroids. Etched with HNO3 and HF. 250 ×. Beta within grains and at boundaries, but not segregated, in ingot with 0.544 Fe; 1.024 Fe gives more beta grains and medium segregation.

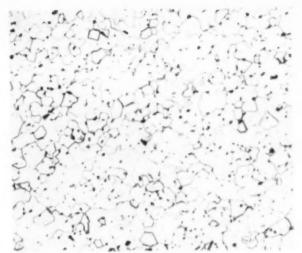


Fig. 3-Ingot C-0.22

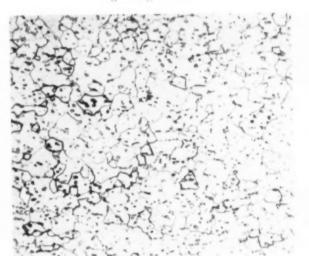


Fig. 4-Ingot C-0.54



Fig. 5-Ingot C-1.02



Irwin Cameron Mackie

An Eminent Canadian Metallurgist

OF THOSE WHO have served their day and generation through the medium of their chosen profession, the name of Cameron Mackie ("Cam" to his associates) is outstanding.

In these days of ever increasing speed, safety assumes growing importance. Particularly is this so in the matter of rail transportation.

Years ago—in 1911 or thereabouts—a fatal derailment on the Lehigh Valley Railroad—broke one rail (in track only ten months) into 27 pieces! This focused attention of the U. S. Interstate Commerce Commission on a matter that had troubled railroad and railmill men greatly as weights of rails and speed of heavy engines kept increasing. The best of the rails were seemingly unable to take the punishment.

One very common type of fracture evidently started from an internal defect, in the central zone of the rail head. These cracks were so common they acquired a name-"shatter cracks" or "internal transverse fissures". One faction held that such cracks developed in originally sound rails, and were due to service stresses of too great a magnitude, but in 1919 two metallurgists with the Pennsylvania Railroad (F. M. Waring and K. E. Hofammann) found what seemed to be shatter cracks in new rails never laid in track. The alleged cracks were disclosed by etching sections cut from the center zone of the railhead. Railmakers for some time refused to admit the existence of cracks in new rails. They attributed the cracks to the effect of strong, hot acid on such hard steel containing internal stresses of considerable intensity. The acid produced the cracks, it was maintained, instead of revealing a defect as alleged. It did not take long, however, for impartial investigators to prove the existence of real cracks in many newly rolled rails,

Certain eminent metallurgists who studied the cracks in new rails were emphatic in asserting that they were formed while the rails were red hot—in fact above the critical temperature—this judgment being based on the paths of the cracks in relation to the microstructure.

After it was experimentally proven that samples cut from rails at the rolling temperature, and buried in lime for slow cooling, were invariably free from shatter cracks even when the corresponding rail, naturally cooled, contained many cracks, nothing was done about it because such slow cooling softened the rails unduly. This was thought to be unavoidable because of the accepted opinion that the cracks formed above the critical temperature.

This generally accepted theory as to the birth of the defects failed to convince Cam Mackie. By a series of tests which, in retrospect, look extremely simple, he discovered that the cracking occurred at a comparatively low temperature, long after the rails had hardened in cooling and had lost their red heat. It remained only to accumulate a sufficient amount of evidence with the various sized rails, to fix the temperature zone in which retarded cooling was required and the degree of retardation necessary to eliminate the shatter cracks. Finally Mackie found that if some 100 rails were placed in a suitable iron box while they were at a temperature between 660 and 930° F. and kept there about 15 hr. until cooled to 200° F. and then removed, these rails were free from shatter cracks. (Hydrogen in solid solution at high temperature was found later to be the culprit. Given time during slow cooling, this gas could diffuse out of the steel without building up damaging internal stresses.) Hundreds of tests were made, half being treated and half not, with the result that, at the end of two years he could confidently report his findings to the railroads and get them to put treated and untreated rails into tracks for comparative tests.

The retarded cooling process as developed by Mackie at the works of the Dominion Steel and Coal Corp. in Sydney, Novia Scotia, was patented in Canada in 1932 and in many other countries. For many years now practically all rails rolled in the United States and Canada have been "control cooled" as the present phrase goes, and the results in service have confirmed the original belief of the inventor that rail failures would be vastly reduced by the elimination of shatter cracks.

What of the man responsible for all this? Cameron Mackie was born in Prince Edward Island on Nov. 14, 1880. While he was still a boy his parents moved to Brockton, Mass., where he graduated from high school. He returned to Canada and entered Dalhousie University, Halifax, his studies being about equally divided between science and the classics. He obtained his B. A. (magna cum laude) in 1901.

For the first year after graduation Cam Mackie taught school but soon heard of an opportunity that was available in the chemical laboratory of the Dominion Steel and Coal Corp. in Sydney. So it is that in July of 1953 he passed his 51st anniversary with the one corporation, serving successively as chemist, metallurgist, and finally as director of metallurgy and research.

Cam Mackie still puts in a full day's work and is to be found in whatever part of the huge works any metallurgical problem has appeared. His staff speaks of him as an inspiring leader and one for whom it is a pleasure to work. Like many another clever man, Mackie is quiet and retiring by nature. A year or so ago he was offered a Doctor of Engineering degree, Honoris Causa, by Nova Scotia Technical College, but preferred to remain plain Cam Mackie.

He ardently wishes that the present day's crop of metallurgists and scientists training in the universities would take a good dose of classics as part of their training. He feels that it would enable them to write letters and reports that would not require clairvoyance for interpretation.

Cam Mackie has always been interested in sports, following his former activity in football and tennis. In recent years it is curling in the winter and golf in the summer. Lest the subject of this sketch should be thought to be unusual, it should be noted that his golf is erratic, a mixture of pars and double-figure holes.

"I am a bit of a heretic," he says, "but I still support the Church in the perennial hope that it will get into the present century." Especially is he interested in Y.M.C.A. in a realistic and very generous manner. His royalties on rails have never caused him to alter in any way his former manner of living. He is not known as a public speaker but will be found the center of entertainment in any friendly gathering, with his original thinking and ready wit.

Cameron Mackie has been awarded the platinum medal of the Canadian Institute of Mining and Metallurgy in recognition of his metallurgical contributions. He also has the certificate of the American Society for Metals, recognizing his membership in the society for the past 25 years. This certificate and an ordinary calendar are the sole adornment of his plain but roomy office.

Harond J. Roast

The Open-Circuit Thermocouple

A Neglected Device of Considerable Adaptability

In many problems where temperatures must be accurately known it is frequently convenient to spot-weld the thermocouple wires to the metal in such a way as to make the sample under study act as a part of the hot junction of the thermocouple. The method indicates the true temperature of the material and is particularly useful for rapid temperature changes and small sample size.

Phase reactions in a metallic alloy under equilibrium (or quasi-equilibrium) conditions are commonly studied by so-called heating or cooling curves. The elementary metallurgical laboratory experiments have been greatly refined for precise work by physical metallurgists, but usually a fused-junction thermocouple is relied upon to indicate the temperature changes of the material under study. When temperature is plotted against time during heating, a smooth curve will result except when some exothermic reaction occurs in the body under study whereupon the time-temperature curve is displaced in the direction of a higher heating rate (and

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vice versa for an endothermic change). In this technique a fairly large amount of sample material is necessary to produce enough heat change from a phase reaction to affect the normal heating and cooling rates. Sometimes thermopiles and differential thermocouples are used to amplify the thermocouple output or to compare the temperature of the sample and an adjoining metal known to have no phase change to exaggerate the heat variances. However, these usual methods for following reactions during fast heating and cooling result in less and less sharp indications so that it becomes difficult and sometimes impossible to pick out the actual phase reaction point.

When standardizing high-temperature ther-

mocouples, the writer and others have replaced the usual fused junction with a small piece of high-purity metal whose true melting point is known. The individual wires of the thermocouple are joined to the ends of the insert and the junction thus formed is placed in a uniform heating chamber. The thermocouple output is observed until melting occurs. Such melting of the junction gives a very sharp end-point on the e.m.f. output and a calibration point is obtained.

To distinguish this device, the author refers to it as an "open-circuit" thermocouple,

Extending this technique to studies of reaction in the solid state, the individual wires of the thermocouple are spot welded to a small piece of the material under scrutiny. The validity of such a device is supported by the theories of thermo-electric phenomena in consideration of the presence of a third dissimilar metal in a thermocouple circuit. When the third dissimilar metal is the sample, as in the open-circuit thermocouple, the temperature indicated by the thermocouple circuit is a function of the temperature at the two spot welded junctions: therefore, it is necessary to have the two junetions at the same temperature. The open-circuit thermocouple will not indicate temperature variations of the material between the spot welded junctions unless such variations include the area of the junctions. For correct usage the entire sample between junctions, and also the junctions, must be at the same temperature.

When the size of the sample is kept small, its true temperatures are obtained by observing the thermocouple output during heating or cooling. Actually, the size of the sample should be immaterial if the temperature is reasonably uniform throughout the specimen, but since most such investigations are done while the sample is heated by radiation or conduction, a large sample may result in fairly large temperature differences. If fast heating rates and fast cooling rates are involved, one is usually forced to use small-sized samples. The reaction heat is then correspondingly small - sometimes too small to be clearly indicated with the regular fused-junction thermocouple placed alongside or attached to the sample.

However, with the open-circuit thermocouple substituted for the usual fused-junction type, phase change reactions have been determined in a large number of materials and at temperatures ranging from -40 to 1000° C. (-40 to 1830° F.) and there is no reason why the temperature range cannot be extended. Sample size has varied from 5-in. cubes to 5-in. diameter rods 2 in. long and 1/16-in. disks up to

\(\frac{1}{2} \) in. in diameter. Generally the open-circuit thermocouple was joined to the sample with a maximum of distance (on the surface) between the two junctions so there was no criterion of inter-wire spacing. The wires were usually spot welded to the surface of the sample. (For comparison, a regular fused-junction thermocouple was often inserted into a hole in the sample.)

During some tests, heating rates up to 170°C. (300°F.) per min. were used; however, most of the tests were made at heating rates of about 10°C. (18°F.) per min. in order to standardize the technique. Cooling rates have not been critically determined, but the austenite-to-martensite transformation has been indicated.

Other work by the author has utilized the open-circuit thermocouple in phase reaction studies at heating rates up to 260° C. (470° F.) and cooling rates to 420° C. (750° F.) per min.

The open-circuit thermocouple also has been used by the author to determine the melting points of certain fusible alloys. The maximum liquidus temperature in which this technique has been used so far is about 300 °C. (575 °F.). In these tests the bare thermocouple wires were held parallel, 5 in, to 1 in apart, and were inserted from 5 to 4 in, into the liquid so that direct physical contact was made between wire and liquid alloy. Liquidus temperatures and some solid state reactions were recordedusually with exaggeration of the phase break. With the deeper submersions the crucibles were not under uniform temperature and small discrepancies were noticed. However, phase reactions were recorded which occurred in the lower half of the melt due to monotectic reactions and double liquid separation. It is not clear yet if they were picked up by the wires in the lower liquid (or solid) or if the heat effect was conducted through the upper liquid (or solid) to the surface contacts of the thermocouple; the latter is probably correct, but even then one merely needs to insulate the wires from the surface contact and place the opencircuit wires in such a way as to minimize conduction losses

Other Possibilities—It seems possible to extend this technique to the measurement of temperature and high-speed temperature changes of materials and machines. The operating surface temperatures of parts could be measured rather easily without disturbing the continuity or contour of the section, and since the method determines the actual temperature without requiring heat transfer by conduction to a second body, results should be more accurate.

Ten Practical Uses of Statistical Quality Control in Metallurgical Plants*

Time time contribution to the Philadelphia Chapter's series on "Practical Applications of Statistics in Laboratory and Production" must necessarily be limited - by virtue of a desire to speak from personal knowledge - to data from Aluminum Co. of America's operations. It will be slanted toward the application of statistics to production of aluminum stock for sale to intelligent purchasers. It will bear stating at the very outset that uniform quality, high enough to meet the requirements of use at the lowest possible cost, is the objective of such a control program.

No one should conclude that statistics are a substitute for quality control. Statistical analysis is a very valuable tool in the hands of a competent quality control man, just as a slide rule is useful to an engineer. Neither statistics nor a slide rule, however, is a substitute for integrity, sound metallurgical thinking, and technical skill in the control of quality of products in the metallurgical industry.

Quality of the final product - say an aluminum disk - starts clear back with the raw materials, such as the bauxite ore. Control through the ore refining and smelting steps centers on composition as determined by chemical analysis. Alcoa's operations include fabrication of various useful forms, ranging from castings to wire, forgings to paint.

Obviously the control of quality of these items involves not only composition but also mechanical properties, dimensions, internal quality, surface quality, and various particular characteristics required by specific uses.

General Organization - Quality control begins when the salesman gets the order or arranges for a price estimate. He must record a complete description of what the customer wants and applicable specifications (if any),

Each customer and Government specification is submitted to the specification department of the metallurgical division. Pittsburgh, for careful scrutiny. Its responsibility is to approve all specifications or to note exceptions to any requirements with which Alcoa products do not comply. The sales and manufacturing groups

are notified of any exceptions.

A "Quality Requirement Record", as reproduced in Fig. 1, may be used where a description of the customer's operations and use requirements will result in a clearer understanding of the quality required for sheet prodnets. Before filling special orders the manufacturing plant also makes a "Special Practice Record", which is sent to the quality standards department of the metallurgical division, Pittsburgh. This department scrutinizes the Quality Requirement and Special Practice Records as to all technical matters and distributes approved copies to all responsible personnel in the Alcoa plants that may be called upon to manufacture the items in question.

Standard manufacturing practices, covering the details of all processes, are recorded by the Works' metallurgical departments. These records are coordinated for all plants by the metallurgical division, Pittsburgh. It is the responsibility of the metallurgical department for each manufacturing division to maintain

^{*}Report of a Lecture by John W. Hood, Head, Quality Standards Department, Metallurgical Division, Aluminum Co. of America, Pittsburgh. Given before the Philadelphia Chapter, American Society for Metals, March 25, 1952.

uniformity in practices between the plants manufacturing identical products, within the limitations in equipment available at each plant. Control limits in composition, mechanical properties and other characteristics are maintained by the metallurgical division, Pittsburgh, and are used as a guide for quality control by the various plants.

Let us, in the interest of brevity, confine our attention to the use of statistics in the control of quality in such manufactured objects. Each manufacturing works has, in its organization, at least one man trained in the application of statistics to quality control, and the use of statistics in each plant is coordinated by a

member of the metallurgical division. Pittsburgh. Experience has shown, however, that statistical quality control cannot be applied universally. For example, the brightness of aluminum sheet is important to some customers and is evaluated primarily from the standpoint of appearance, rather than by a measurable standard. Therefore, statistics are not applicable,

Presented herewith are tencategories in which statistical control has practical uses.

TEN PRACTICAL USES

L. Quality Assurance - The preceding highly informative papers in this series by Dr. Youden and Professor Burr have given an idea of the mathematical basis of the subject. They have stressed the fact that successive objects in mass production actually do vary; also that the measurements themselves have inherent variations. Information has been given in these papers on the units for measuring this variation, and means whereby one can estimate whether the variation is "normal" or "out of control".

Important manufacturing variables in an aluminum product – for example, a strong aluminum alloy sheet –are composition of the

Practice in the Aluminum Industry

alloy, temperature and time of solution heat treatment, speed of quench, intermediate heating operations, amount of cold work, and grain structure. This is a rather formidable list, but Fig. 2 shows the net result of control of the many variables in manufacturing a specific class of sheet. The solid curve shows the distribution of the approximately 40,000 actual mechanical property test results of the product as manufactured at several Alcoa plants during 1936 to 1940. The small circles show the distribution of some 20,000 tests representing the product as supplied in 1940 and 1941. Although

Fig. 1-Representative Record to Be Prepared by Salesman as an Aid to Manufacturing Works' Understanding of Quality Requirements of Sheet

	QUALITY REQUIREMENT RECORD Sheet Products						
Date Issued_	Record No	Record No					
Alcoa Product	Customer						
End Product	Address						
Order No	Item No Date Order Entry						
Description o	of Alcoa Product:						
	USE INFORMATION						
End product :	will retain original - Thickness Length Finish width Diameter Use: Structural Ornamental Utility	h 🖂					
Customer will	1 perform following operations:						
Cutting	Working Joining Finishing						
Blank Machine Rout Saw Shear Slit	Bend Braze Anodize Brake Form Weld Clean Press Form Butt Etch-Acid Draw Butt Etch-Caustic Forge Torch Paint Roll Form Rivet Polish Spin Finish only One Sid	le					
Important que	ality factors for product as supplied:						
Measurable	Metallurgical Visible						
Diameter Length Squareness Straightness Thickness Width	Brightness Smoothness of Edges Uniform Appearance Smoothness of Surface						
Requir	e only One Good Side 🖂 Identify Good Side 🖂						
Remarks:	Data Supplied by						

Composition Control

every piece of sheet was not tested, it is obvious that the process variables were controlled within essentially the same ranges during the two periods. As a result, the product can be used with confidence.

This represents, then, an example of one of the valuable uses of the tool known as statistical quality control – namely, assurance that the product has certain desirable characteristics.

II. Operator interest is a second valuable use of this tool. The need for controlling alloy composition within prescribed limits has been mentioned. This involves not only the use of alloy and pig charges of known composition and in the right quan-

tities, but also the proper mixing and blending of the materials in the molten state. For this important task, dependence is placed upon the furnace operator, and the quality of his performance is checked by chemical analyses of samples taken at regular intervals from the

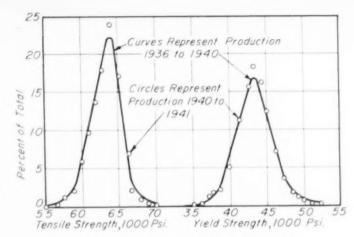


Fig. 2—Lines Show the Frequency Distribution of Some 40,000 Inspection Tests on a Specific Class of Aluminum Alloy Sheet Made in 1936 to 1940. Circles represent similar results for the next two years; their location close to the lines is assurance that all process variables remained within the formerly established ranges

melt. These analyses are of major importance since the ingot or ingots cast at the time are held in bond, so to speak, until the chemistry is approved as being within the required specification limits. No analysis of slabs or finished sheet or shapes is made during fabrication.

> If the analysis of any sample goes out of control limits. action is taken to determine the cause and correct it. It has been demonstrated that placing control charts at the furnace in view of the operator, results in more accurate performance. By seeing the results of his work, he not only is given a sense of pride in keeping the composition within the limits, but also is able to see when a minor letup in his efforts causes a slight deviation, even though it still may be within limits.

In other words, everyone likes to see the results of his work and takes a more active interest in doing it right if he

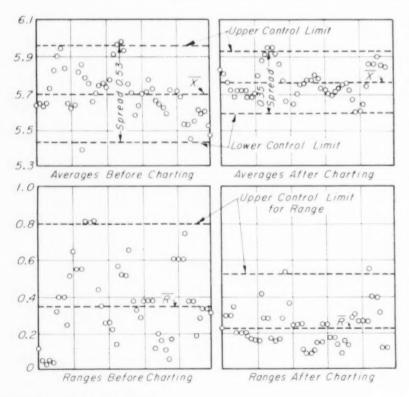


Fig. 3—Chemical Analysis of Furnace Product Is Under Closer Control (as at Right) When Test Results Are Posted at the Furnace so Operator Can Watch His Own Performance,

is made a part of the team. Statistical control charts help accomplish this important result. Figure 3 represents an actual case, note the closer control limits applicable after charting.

III. Basis for Decisions — There is the story about the apple grower who hired a man to count apples for him. After the counter had been at the job and very happy doing it for some time, the boss asked him to start separating the good ones from the bad ones. After a short time at this job, the formerly happy apple counter became very unhappy and his health began to fail. His troubles stemmed from the mental strain of having to make all those tough decisions!

It is a fact that most people do not enjoy making decisions. While baseball fans like to razz the umpire, very few want to swap places with him. This introduces a third valuable use of the tool, statistical quality control – namely, that of providing definite rules on which to base decisions.

Alcoa manufactures great quantities of "circles" which are actually disks blanked from sheet stock. They are used for making cooking utensils, cans, lids, and so on. Until about five years ago, each one of these circles was inspected individually and there were literally millions of them. It was called "100% inspection". It is known, now, as it was suspected then, that 100% inspection is impossible because of the monotony of the task, the fatigue factor, and the fallibility of human nature.

To solve this problem, a sampling plan was selected from the so-called Dodge and Romig tables worked out by mathematicians for the inspection of parts for telephone apparatus. The specified number of circles is selected at random from each manufacturing lot, as prescribed by the tables, and each disk in this sample is carefully inspected. If the quality of the sample meets the predetermined standard, the lot is passed without further inspection. If the sample fails, the lot is set aside for detailed inspection of each piece. While the need for decision remains, the number of decisions required has been reduced by a tremendous margin.

Damage from excessive handling of the product has been minimized. Furthermore, the inspector has more opportunity to call on his superior for help in the doubtful cases. Figure 4 shows this inspection operation. It insures that the average outgoing quality level is as required; obviously, it does not prevent the occasional shipment of defective pieces, but neither did 100% inspection.*

Inspecting Blanked Disks

IV. Incentive to earn low inspection cost is also illustrated by the above instance. Operating management can earn low inspection costs without risking any reduction in the quality of the product shipped. A daily record of the number of lots requiring 100% inspection (or "detailing") is prepared. The cost of this inspection is, of course, greater than for those lots which are passed on the basis of a sample only. If the number of lots requiring detailing goes up, those in charge have an immediate incentive to correct the cause. Furthermore, there is less tendency to blame high scrap on what the inspector had for breakfast. Thus, sample inspection has enabled the operating management to carn low inspection costs by keeping the quality up.

V. Establishment of Customer's Standards — The aluminum industry, as is true of others in the metallurgical field, has a great many customers which manufacture a wide variety of products for different uses. There is considerable difference in the quality standards required for aircraft sheet as compared with roofing sheet, architectural spandrels as compared with engine pistons, railroad car structural extrusions as compared with kitchen trim, and beer barrels as compared with toothpaste tubes. However, each use has definite quality standards.

Take, for example, aluminum collapsible tubes used for packaging toothpaste, cosmetics, and all sorts of thickened fluids. Figure 5 shows a control chart set up to record wall thickness to the requirements of a certain use. It would be a hopeless task to inspect each tube for wall thickness. However, by agreement with the customer, this dimension is controlled within

*In the discussion, after this lecture had been presented in Philadelphia, Mr. Hood was asked whether there were circumstances when 100% inspection would be necessary. His reply was:

"The requirements of the next operation or of the final service determine the type of inspection required. Where a statistical sampling plan is applied, the desired quality level is assured mathematically. There is evidence that there is a greater chance for defectives being accepted, particularly in borderline cases, with 100% inspection than with a sampling plan. However, some very critical items should have 200, 300, and even 400% inspection. Of course, this applies usually to finished items whose failure in service would involve grave risk.

"All items in a lot which have been rejected in a sampling plan are inspected. This 100% inspection is in the nature of a salvage operation, since it is known that such a lot contains a large proportion of acceptable material, and it is usually economical to separate the good from the bad rather than to manufacture an entirely new lot."

More Uniform Collapsible Tubes

specified limits and the chart records are accepted as proof that the product meets specifications. This particular chart also portrays the results of certain improvements achieved as the result of statistical quality control.

Information is being sent to Aluminum Co. of America from customers with increasing frequency, indicating that they are rating the quality of material received by an acceptance sampling plan. Instances are manufacturers of zip-

pers of aluminum alloy wire, where (as every American knows) lack of dimensional accuracy means you're hopelessly stuck! Another is the manufacture of aluminum alloy rivets for countersunk holes, where flush heads are important. A head too high must be ground down; a head too low means a loose rivet. Control charts are invaluable to determine the accuracy of the heading machines; 100% inspection of the millions of products would be hopeless.

VI. Government inspection of material to be used by the armed services has utilized statis-

Fig. 4-Inspection of a Sample of Aluminum Disks



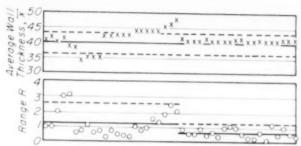


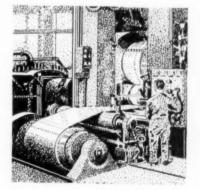
Fig. 5-Inspection of Samples of Collapsible Tubes for Wall Thickness, 1 In. From Bottom. Right half of chart records more uniform conditions after an improvement in the manufacturing process had been made

tics to a growing extent since the Army Service Forces, Office of the Chief of Ordnance, issued the first "Government Standard Inspection Procedures Based on Statistical Quality Control" in the year 1944.

A relatively new specification, known as MHL-STD, 105A, dated Sept. 11, 1950, has been issued as a "bible" to guide inspection by sampling and will, undoubtedly, play an increasingly important role in governing the rules of inspection of Government purchases.* It permits a variety of choices of standards depending upon the final use of the part or material in question. By means of tables and operating characteristic curves, the degree of risk involved in the use of any given plan can be predicted; this is valuable for both the vendor and purchaser. One feature of the tables is that they permit the frequency of inspection to be reduced as long as the quality remains above a certain level, but require more frequent inspection when the quality drops. These tables also recognize a difference in acceptability between major and minor defects in a particular product.

The principle involved here is that the Government is in fact inspecting a manufacturing

process as reflected in the quality of its product. If there is mathematical assurance that the process is in control, there is no reason to spend unnecessary effort and expense in inspecting the product. This approach, as employed by the Armed Services, is one of the few items of good news to the taxpayer. As a matter of fact, this is the heart of inspecting by statistical methods.



Government Sampling Tables

VII. Tolerances for Machines and Methods—To explain this seventh function of statistical quality control, we will revert to the problem of maintaining the composition of aluminum alloys within the required limits. The first step in the solution of this problem is to establish the limits based on the relation of the characteristics desired to the accuracy of which the process is capable. Weighing out the components of an alloy on laboratory scales and melting them down under carefully controlled conditions in a

pint-sized laboratory furnace will result in closer control of the composition than operating on a production basis in a 25-ton openhearth furnace to which the charges are added from time to time and from which part of the metal is tapped between charges. Nevertheless, the composition must be controlled as closely as practicable in production.

How close is "practicable"? This can be determined mathematically by operating the furnace under careful supervision and taking samples at frequent intervals. By an analysis of the data, control limits are established and the process can be continued with these control limits as the guide.

Similar methods are employed to establish dimensional tolerances for thickness of sheet, angularity and straightness of extrusions, core dimensions in castings, flatness of plate, diameter of wire, head heights of countersunk rivets, and so on almost indefinitely where the variables are subject to measurement.

VIII. Control of Laboratory Methods — Each Alcoa Works is equipped with an analytical laboratory which makes all the routine analyses. Each laboratory uses approved methods and equipment. Periodically some neutral party —

for example, the manager's secretary – visits the Works laboratory and selects at random a metal sample which has been analyzed. The sample is turned over to a research chemist at Aluminum Research Laboratories in New Kensington for his analysis. The two results, independently found.

^{*}Statistical process control is also recognized in the new Military Specification MIL-Q-5923.

Planning Experiments

are then compared. Based on a great many such comparisons, standard deviations have been worked out which are used as a guide to determine the accuracy of the methods, the performance of the individual laboratories, and the evaluation of new methods and techniques.*

IX. Technical Experiments – Much valuable plant metallurgical work has been done without the aid of modern statistical methods. However, many observations and conclusions have been influenced by preconceived notions of what the results should be. Statistical analysis not only minimizes the chances for erroneous conclusions, but also enables the experimenter to plan his experiments with

the minimum number of samples necessary to permit him to draw valid conclusions. This has been well expounded by Professor Burr in his article in *Metal Progress* for October 1953, and therefore needs no further elaboration here.

X. Labor Relations — The tenth and final example of the use of statistical quality control deals with the suggested use of this method in the field of labor relations. Applications to machines and methods have been discussed. Statistical quality control is also applicable to men. Without mathematical analysis it is possible to draw erroneous conclusions as to the

Statistical quality control is also applicable to men. Without mathematical analysis it is possible to draw erroneous conclusions as to the *Some queries at this point during presentation of the paper in Philadelphia brought out the fact that spectrographic analysis is in widespread use in Alcoa's control laboratories. Standard methods and standard samples have been formulated by the company's central research laboratories in New Kensington. Work along this line started about 40 years ago and is still under way. Mr. Hood observed that the use of a standard sample for spectrographic or quantometric analysis does not eliminate possibilities of errors from many sources, such as the preparation of the samples (either in casting or machining), in the sparking of the samples or adjustment of the equipment. Accuracy of routine laboratory analyses by wet methods as well is checked by the Aluminum Research Laboratories. Those interested in this phase of metallurgical control should consult two articles by H. V. Churchill and J. R. Churchill on "Evaluation of Spectro-

graphic Analytical Data" which appeared in *Industrial and Engineering Chemistry*. Dec. 15, 1945, and Jan. 15, 1946.



Since graduation in 1921 from Lehigh University, John W. Hood has been with Aluminum Co. of America, and until 1944 did metallurgical work at various plants. Since that date he has been in quality standards and customers' service work in connection with all forms of aluminum and magnesium alloys. At present he is head of the quality standards department of the metallurgical division in Pittsburgh.

range of quality reproducible by a man or the amount of work of which a man is capable, just as easily as it is to misjudge the characteristics of a process. Furthermore, it has been demoustrated repeatedly that men take more interest in their work if they see the results of it as portraved by control charts. It is true that when the facts are presented on a mathematical basis, a man has more confidence in them than when he is merely told about them in general terms by his foreman. Furthermore, the foreman has more confidence in talking to his men if his story can be backed up by facts on paper.

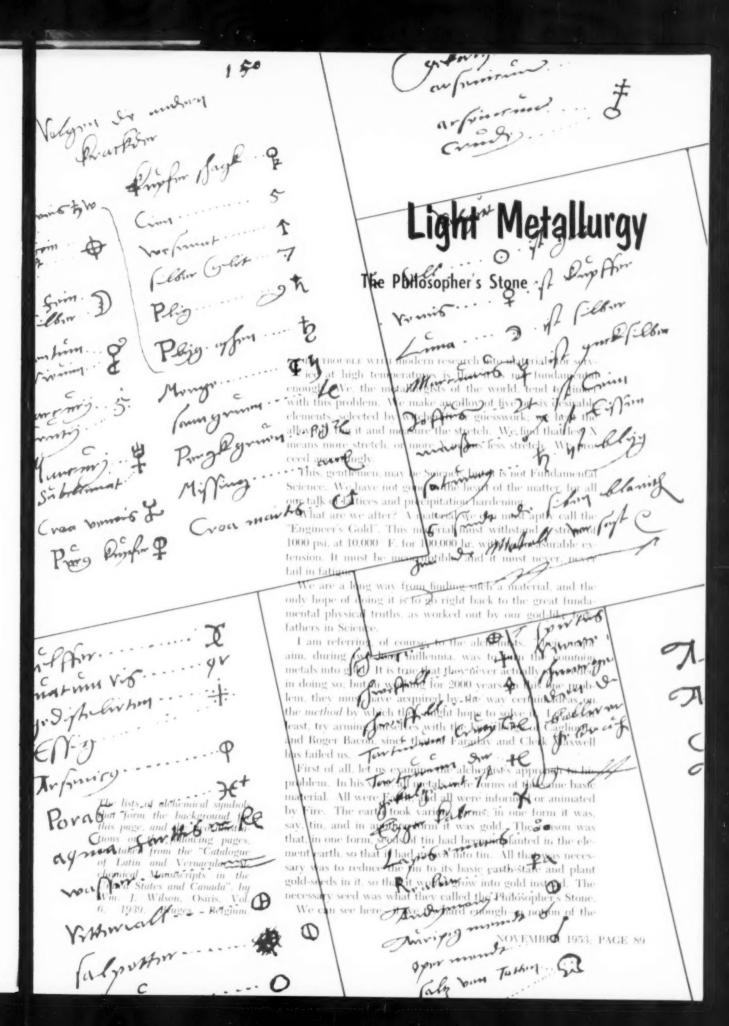
PRACTICAL USES

In summary, we may list a rather imposing series of

practical uses of statistical quality control, as proven by experience in Aluminum Co. of America's operations. Some of them may appear a little bizarre. At any rate, they are far from the assemblage of dots on coordinate paper which rugged individualists of the old school have called "doodles" or "flyspecks". Given a friendly managerial atmosphere, many, if not all of them, can be achieved in any metal-lurgical plant engaged in mass production.

- L. Quality Assurance
- II. Operator Interest
- III. Basis for Decisions
- IV. Incentive to Earn Low Inspection Costs
- V. Customer Quality Standards
- VI. Compliance with Government Inspection Standards
- VII. Establishing Tolerance Machines and Methods
- VIII. Control of Laboratory Methods
 - IX. Planning Technical Experiments
 - X. Aid in Labor Relations

No one industry has a corner on these problems of human relations and costs, and it is hoped that the examples cited from Alcoa's experience can be translated to those in other activities, in such a manner that they will be interesting and useful.



Superalloys by Alchemy

underlying unity of matter which is not altogether distinct from our own atomic theory. At least, the belief that we can see it may give us enough moral courage to continue our search.

The alchemist was not simple enough to believe that tin, as tin, was capable of being turned into gold by the mere addition or subtraction of anything. The tin had first to be utterly destroyed, and reduced to its basic form. The entire process was a kind of destruction and resurrection, similar to that which occurs in the growing of any other crop. Corn produces seed, and dies away; the seed, destroyed by burial, produces more corn, but only if it is planted at the right season and with a certain decent ritual. It is no use putting a lot of seed into a barrel in October and expecting to find a cellar-full of corn at Christmas. Hence arose a lot of what we now regard as mumbo-jumbo in the alchemic art. If it is reasonable to expect that seed planted in autumn will rot, and seed planted in spring will grow, it is also reasonable to expect that the successful flourishing of goldseed may only take place at certain phases of the moon, with the assistance of the drawing of pentagons, the wearing of suitable robes, and the banging of gongs.

Some metallurgist may be rash enough to interrupt me at this point to ask if I am seriously suggesting that he should melt up a lot of nickel, chromium, tungsten and vanadium in a pot and slit the throat of a yearling weasel over it by the light of the full moon, uttering at the same time certain carefully chosen passages from, say, the 1951 * Transactions in a high monotone.

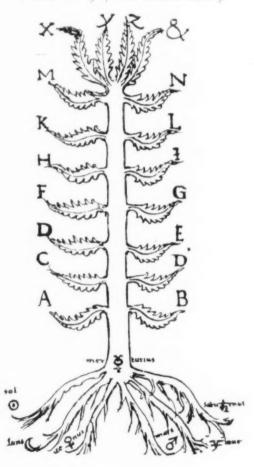
Lask him in return: "Has he ever tried it?" After this crushing retort, let us proceed with our inquiry. We encounter, as we look further into the works of the alchemists two serious difficulties. One is that it is extremely difficult to understand, at any given moment, what the alchemist is talking about. His writings resemble the official statements about the atomic bomb tests in Nevada in that he is not trying to impart information; he is trying to conceal it. He has to lure the reader on by promising to disclose the secrets of the universe, but the revelation is, to say the least of it, cloudy. The alchemist was impelled, like all scientists, to publish the results of his work; but if he thought he was getting near to discovering the secret of the Philosopher's Stone, he did not want a thousand Toms. Dicks and Paracelsuses to read his recipes and get there first, ruining the market with a flood of

cheap gold. On the other hand, if he thought he was a long way off and getting no nearer, he did not want to give his failure away. In either case what he did was to wrap his ideas in a lot of the most unutterable clotted nonsense that can be found in any section of the world's literature.

The other difficulty is that when the alchemist talks about tin he is quite often not talking about what the world commonly regards as tin. He is talking about Sophic Tin, a kind of pure, tin-minded tin, the abstract ideal toward which all tin is aiming, although it never reaches it.

This confusion led a lot of alchemists astray. It was common knowledge in those days that all metals were composed of sulphur and mercury in varying proportions. The metallurgist may protest that I said previously that all metals

Fig. 1 – The "Tree of Metals" With Sol, Luna, Venus, Mars, Jove and Saturius as the Boots, Mercurius as the Trunk, and Opposite Pairs of Leaves A through M. Culminating in a Top Cluster Marked X. Y. Z. &. (Courtesy of Osler Medical Library)



were earth informed by fire. So I did. The statements are quite consistent. The earthy or mineral part of the metal is symbolized by mercury, and the fiery or combustible spirit of metals is represented by sulphur.

The ordinary common-or-garden alchemists, the hard-working bellows-blowing fellows who were universally referred to in the Middle Ages, with friendly sarcasm, as "puffers", wasted a lot of time trying to synthesize gold from common mercury and sulphur. They used to boil up these materials together in a crucible (or Philosopher's Egg), or distill them from an alembic and condense the vapors, weaving pentagrams over them and what not. It did no good. All they ever got was a deplorable stink. If they had acquired financial backers they often put some real gold in, and they knew enough about cupelling to get it back; but they never got out any more than they put in.

The real, genuine alchemist knew better. He

Fig. 2—This Alchemical Recipe not Only Produced no Gold but Destroyed Half the Silver Put Into It. "ideo non tantum est falsissimus, sed ctiam rapacissimus". (Courtesy of Harvard College Library)

Exercise profess of resultances can foun for exercise to come of the profess of the profess of profess of the p

The Search for Engineer's Gold

knew that his starting point for the synthesis (the Great Work, as it was called) must be mercury and sophic sulphur. Often he spent the whole of his days toiling to obtain these materials without ever starting on the real Great Work at all. The wisest alchemists of all were more fundamental still; they never so much as touched a bellows from one phase of the moon to the next, but spent their lives poring over old manuscripts, trying to find out how the trick had been worked by the ancient Egyptians, who notoriously knew all about it. Unfortunately, the Egyptians had wrapped up their knowledge in the usual alchemic verbiage about Set and Nephthys, Sol and Luna, or the marriage of the Faire Whyte Woman to the Ruddy Man,

Besides the controlled growth of goldseed and the synthesis from the sopic pseudomorphs of sulphur and mercury, these wise old alchemists opened up other

avenues which might well be explored by the latter-day metallurgist in his search for the Engineer's Gold. There is, for example, the conception of tingeing:

The alchemists, analyzing the essential differences between gold and the common metals, observed that most of the latter were gray and, so to speak, combustible; while gold was yellow, and incombustible. The yellowness, as they saw it, might be a product of the incombustibility might be a product of the yellowness. If you could only tinge zinc, or lead (or washing-soda for that matter) to the precise color of gold, it might well turn out actually to be gold!

There is a lot of work to be done still on this tingeing business. We are faced at once with the difficulty that we do not know precisely what may be the tinge of the engineer's ideal creep and fatigue resistant material; but such difficulties exist only to be surmounted. If there is no other way of finding out, there is bound to be, somewhere, an ancient Egyptian or pre-War German manuscript which will tell us.

I hope I have said enough to inspire a few metallurgists with the idea of tapping the wisdom of the alchemists of the past. There is only one thing that makes me nervous, and that is that the engineers might cotton onto the business and declare that the high-temperature material they require in addition to possessing all its other unimaginable virtures, must also be sophic.

R. P. LISTER

Atomic Energy in Postwar Britain

BY H. W. B. SKINNER*

As EVERYONE KNOWS, we exploded our first trial bomb at Montebello in September of 1952. Since some of Britain's best scientists worked with American scientists on the bomb-design project, you may think that this was slow going, but it must be remembered that during the war most of our atomic energy organization had been merged with yours, or engaged in building up Chalk River in Canada. At the beginning of 1946, therefore, it was necessary to build up from scratch, without the advantage of full cooperation. Since the U.S.A. was building up the stockpile of bombs as rapidly as possible, there was no overriding incentive from a strategic point of view for us to get on quickly with a much smaller one of our own.

Contrary to the expectations of most of the senior scientists who had worked in the wartime project, the Atomic Energy Organization was placed firmly within the Civil Service. I thought at the time that this was a serious mistake, and my opinion has

not changed with the passing of years.

Although the salaries of the bottom and middle grades have now become satisfactory, the top-grade salaries in the establishments, especially engineering, are still far less than in corresponding industrial posts. More fundamentally, there is the fact that Civil Service scientific establishments always seem to run into stagnation.

Very few details about the Atomic Energy Establishments have been given to the public other than

to list their functions:

Harwell, Berks., for research into nuclear physics and atomic energy, and the provision of basic scientific data.

Amersham, Bucks., a subsidiary of Harwell concerned with chemical preparation of natural radioactive substances and radioactive isotopes.

Risley, Lancs., for the design and operation of plants for producing fissile material.

Springfields, Lancs., for the preparation of pure uranium from ore concentrates.

Windscale, Cumb., for the production of plutonium in atomic piles.

Capenhurst, Ches., for the separation of U²³⁵ by diffusion.

Aldermaston, Berks., for research work on atomic

These establishments were officially stated to be engaged on "atomic research, development, and production for military and civil purposes". From 1946 to the end of 1951 the cost has been roughly \$280,000,000.

It has been officially stated that in this country we do not propose to go ahead with propulsion engines until experience has been gained on stationary plants. However, on account of the wasteful and increasing use of ordinary fuels during this century, there seems little doubt that during the next century the world will be in desperate need of new fuel.

The coal fields of Britain have been estimated to have an economic life of 200 to 300 years, at the current rate of use. But real costs are already rising in spite of increased mechanization of the pits. There is no possibility that power from waterialls, wind, and tides can take over any appreciable fraction of the load. Although there is an enormous untapped source of energy in sunlight, this is probably going to be difficult to use without turning over vast acreages of otherwise wanted agricultural land to fuel production.

Therefore, in spite of all the known disadvantages of uranium as a fuel, the world in the course of the next century or so may have to turn to it as one of its main fuels, if not the most important.

Of course, we are well aware of the difficulties involved in the effective use of the U238 isotope and of the large capital charges for plant, as well as the cost of difficult and expensive chemical recycling processes on the material, But such details may be almost irrelevant, if we decide the world will have to make use of uranium to supplement coal, rather than trying to assess whether it can compete with it economically on present-day terms.

Further, in view of the very large capital expenditure which would have to be undertaken to make any significant contribution to total world production of electric power, and of the time-scale suggested for the exhaustion of present fuel reserves, the sooner we get on with the job the better off

we will be.

It has been stated officially that an experimental atomic power station will be built on a site adjacent to the Windscale plant, as part of a double program designed to test the possibilities of natural uranium piles and of breeder reactors. I personally would like to see a long-term program for Britain put in hand to add, by the end of a 20-year period. at least 10% to our national installed electric generating capacity of 16,000,000 kw. Such a program would be quite feasible. The current rate of expansion of our ordinary generating capacity is quite considerable, and a large capital expenditure is in any case being put into the industry. The cost per kilowatt of installed capacity in atomic power stations is likely to be high, but, even so, the expense of a program such as I have outlined should not be excessive. It would give a long-range objective and a considerable degree of stability to our atomic energy project, besides adding a modest contribution to the total resources of the country and preparing the way for the future.

[★]Dr Skinner was deputy director at Britain's Harwell Atomic Energy Establishmeat from 1946 to 1950. The quotations are from a copyrighted article in Bulletin of the Atomic Scientists, June 1953.



Metallographic Structures in Commercial Titanium

By ROMAN OSADCHUK, WILLIAM P. KOSTER and JOHN F. KAHLES*

PIGE TITANIUM can exist in two different forms: (a) body-centered cubic beta above 885 C. (1625 F.), and (b) hexagonal close-packed alpha below this temperature. By the addition of alloying elements, the high-temperature beta phase can be partially or completely retained at room temperature and the phase equilibria at elevated temperatures may also be controlled. If an alloy is heated to an elevated temperature and then cooled in various ways, the phase transformation which takes place during cooling may produce microstructures that will differ widely in appearance at room temperature.

One basic factor controlling microstructures of titanium is the phase relationship at the solution heat treating, forging or rolling temperature. Whether all-alpha, all-beta, or a mixture of alpha and beta is present depends on this temperature and the alloy content. Generally, such alloys contain alpha stabilizers, beta

stabilizers, and both alpha and beta stabilizers, respectively. Alpha stabilizers include aluminum, carbon, oxygen, and nitrogen. Beta stabilizers include elements such as chromium, iron, vanadium, molybdenum and manganese,

If all-alpha is present, there is no transformation during cooling and the microstructure will consist of equiaxed grains of alpha. If all-beta is initially present, several things may occur. Alloys containing large amounts of beta stabilizers will undergo no transformation and all of the beta will be present as equiaxed grains at room temperature; those containing moderate amounts of beta-stabilizing elements will gradnally undergo substantial, but not always complete, transformation to alpha. (In some instances it is possible to retain this otherwise

^{*}Mr. Osadchuk is research fellow in metallurgical engineering at University of Cincinnati, Dr. Koster is assistant director of metallurgical research of Metcut Research Associates, and Dr. Kahles is partner of the same organization,

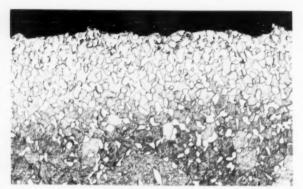
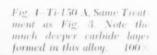


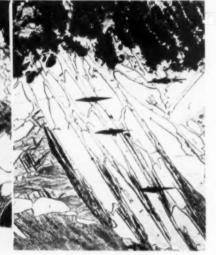
Fig. 1 (Above) — RC-130 B. Heated 4 Hr. at 1800° F., Water Quenched. Shows equiaxed alpha grains stabilized at the surface due to atmospheric contamination. 100

Fig. 2 (Below) – Ti-150 A. Heated 4 Hr. at 1800° F., Water Quenched. Shows needlelike alpha grains stabilized at the surface due to atmospheric contamination. 100%



Fig. 3 - RC-130 B. Pack Carburized in Charcoal 15 Hr. at 1800 F., Showing Carbides (Black) and Alpha (White Particles), 100 -





unstable beta at room temperature by a very rapid quench.) Structures range from grain-boundary alpha and coarse, lamellar alpha produced at slow cooling rates to fine, acicular alpha at very fast cooling rates. Alloys containing little or no beta stabilizer usually will transform rapidly and completely to alpha structure on cooling.

Frequently, these beta-to-alpha reactions are of the nucleation type, but a martensitic (shear) transformation can be produced in some alloys. If alpha and beta are coexistent at the solution treating temperature, the alpha will be unaffected and appear after cooling as equiaxed grains. The beta will undergo transformation in one of the ways just described, depending upon the cooling rate and alloy content. It is apparent from the foregoing that many complex structures may be expected in these alloy systems.

Although there is some variation in hardness and strength accompanying the changes in microstructure, generally this change is not very great. The behavior of titanium alloys in this regard has been disappointing. However, certain titanium alloys can be successfully quenched and aged.

During forging and solution heat treating, considerable amounts of oxygen and nitrogen may be absorbed at the surface of the titanium alloys. The introduction of these alpha-stabilizing elements causes the formation of large grains of alpha at the surface. This alpha is equiaxed in BC-130 B while somewhat needle-

like in Ti-150 A, the external conditions being the same in each case. This condition is illustrated in Fig. 1 and 2. This manifestation of atmosphere. absorption indicates a comparatively slight depth of penetration. However, observation of low-temperature transformations carried out isothermally. which happen to be very sensitive to oxygen and nitrogen concentrations, indicates a gas - sensitized layer up to 0.030 in, thick in MST 2.5Fe-2.5V following a soaking for 60 min. at 900° C. (1650° F.) in air electric muffle furnace. The difficulty of analvzing titanium for oxygen

has prevented further work in this regard.

Pack carburizing of several titanium alloys was also carried out for 15 hr. at 1800 F. The case, easily visible with the unaided eye, consisted of an outer hard but very brittle layer of carbide, and an inner layer of alpha, the latter being caused by the alpha-stabilizing effect of carbon and the atmosphere. This is shown in Fig. 3 and 4.

PHASE IDENTIFICATION

The identification of the several phases appearing in titanium alloys may, at first glance, seem highly difficult. In addition to equiaxed alpha, beta, and beta decomposition products, insoluble phases of titanium such as carbide, hydride and telluride may be present. Therefore, a general knowledge of the alloy systems involved greatly simplifies this problem of phase identification. As in all metallurgical work, accurate information regarding the alloy content of a material and the heat treatments to which it has been previously subjected is highly desirable.

X-ray analysis is particularly helpful in substantiating the predictions and observations of metallographic structures. All-alpha and allbeta alloys can, of course, be identified, but their identity usually can be assumed from the chemical composition. Where alpha and beta co-exist. X-ray analysis can be very helpful in revealing the total amounts of each phase. This can be done most conveniently with a Geigercounter spectrometer to record the X-ray diffraction pattern. In many alloys this determination can also be made by direct optical inspection of the structure, although optical methods generally indicate less beta than is actually present. This statement is made on the assumption that X-ray analysis presents a more accurate evaluation of the existing structure than does optical observation.

Polarized light used on a polished but unetched specimen is very effective in revealing alpha if it is coarse and equiaxed. Under such

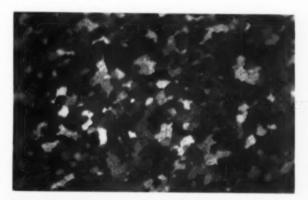
Fig. 5 (Top)—Annealed (As-Received) Ti-100 A. Grain delineation of equiaxed alpha is brought out by means of polarized light. Unetched, 100×

Fig. 6-Ti-150 A. Heated 4 Hr. at 1800° F., Water Quenched. Elongated alpha grains caused by surface contamination. Polarized light, unetched, 100°

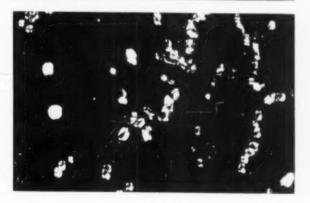
Fig. 7 (Bottom) – MST 5 Fe-5 V Heated 1 Hr. at 1800° F., Water Quenched, Carbides are white and equiaxed beta grains (outlined faintly) are black. Polarized light, etched, 500°

Microstructure of Titanium

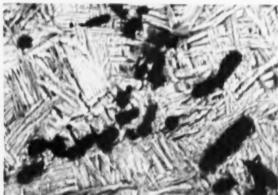
conditions, alpha will alternate between red and slate blue as the polarizing stage is rotated; the beta will remain dark and unchanged. In order to use polarized light successfully, the surface of the sample must be free of scratches and disturbed metal. Magnifications under $500\times$ are preferable. Specimens which have been etched may be examined in this way, but the contrast obtained between alpha and beta is not nearly as marked as in the unetched condition. Fine basketweave structures can be examined, necessarily at magnifications above $500\times$. While an indication as to the phases











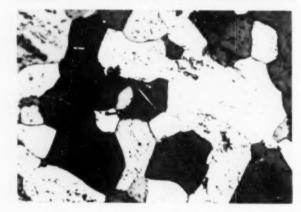


Fig. 8 (Top)=RC-130 B Heated 1 Hr. at 1750° F., Water-Quenched. Heat tinted to show equiaxed alpha (white) and acicular alpha or transformed beta (dark). 500×

Fig. 9 (Center) — As-Forged MST 2.5 Fe-2.5 V. Heat tinted to show carbides (black) and basketweave alpha, 1500×

Fig. 10 (Bottom) – Annealed Ti-75 A. Heat tinted to outline equiaxed alpha grains and give good contrast. 500× present in such structures can be gained, it is believed that polarized light will not produce totally reliable results. Typical structures for which polarized light was found helpful are shown in Fig. 5, 6, and 7.

HEAT TINTING FOR PHASE IDENTIFICATION

Heat tinting has indicated some promise of being helpful in phase identification work. Polished specimens, before and after etching, were heated in air at 500° F. until a light golden-pink film appeared. The surface to be treated was cleaned with ether just prior to the tinting operation, so that uniform oxidation could take place. Carbides in material treated in this way first become bright blue and then darken with longer tinting times. Alpha remains white for some time and then gradually darkens. though not nearly as fast as the carbides. Hence alpha and earbides can be easily distinguished. Transformed beta structures darken quite readily during heat tinting. Furthermore, it is possible to secure grain contrast and much better grain boundary outline in an all-alpha alloy by tinting than could be obtained by even the heaviest etching. The results of some of these techniques are shown in Fig. 8, 9, and 10.

Some distinction can be made between alpha and beta with ordinary etching. Alpha will etch darker than beta in hydrofluoric etchants, providing the material is etched rather heavily. It becomes difficult, however, to identify beta when present in a fine basketweave or acicular structure of alpha.

ELECTROLYTIC ETCHING

Electrolytic etching has proved satisfactory for the differentiation between certain phases present in titanium alloys. P. R. Mallory and Co. suggests electrolytic etching with a 10% sodium evanide solution* swabbed on the surface of the specimen which is polarized anodically. Time and voltage requirements vary widely depending upon the material being etched. A properly treated specimen will appear violet or blue. The carbides will be bright vellow-orange; alpha will be a lighter blue than beta, if both alpha and beta are present. In general, electrolytic etching is a suitable method for phase identification because of the convenient application of staining and because the possibility of structural changes, as might occur in heat tinting, is eliminated. Further work with this technique would seem warranted.

^{*}Such a solution is used to darken carbides in steel. See "Metals Handbook", 1948 edition, p. 397,





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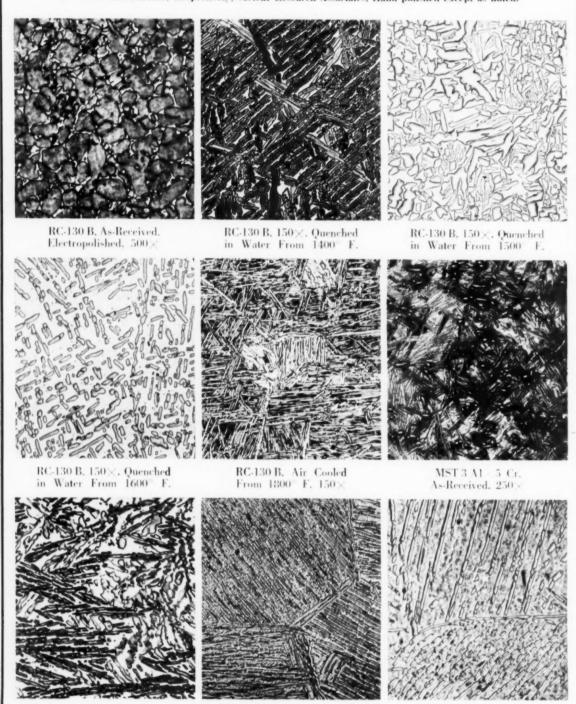
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Typical Microstructures of Commercial Titanium Alloys

Micros courtesy of Roman Osadchuk, Research Fellow in Metallurgical Engineering, University of Cincinnati, and William P. Koster and John F. Kahles, Assistant Director of Metallurgical Research and Partner, Respectively, Metcut Research Associates, Hand polished except as noted.



Ti-150 A. 150×. Quenched

in Water From 1450° F.

Ti-150 A, 150×. Quenched in Water From 1525° F.

Ti-150 A. As-Received, 500×

The motor frame and polishing bowl casting are attached to a steel bracket; the unit can be easily mounted to a laboratory wall.



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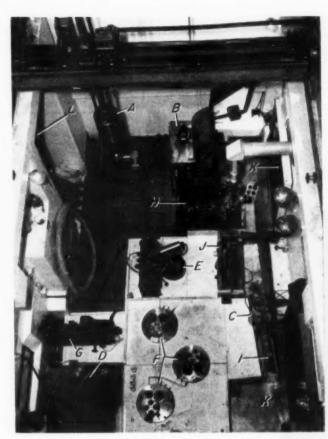


Fig. 1 - Cell Housing the "Hot" Metallographic Laboratory, as Viewed From Above

A - Electric manipulator

B - Cut-off machine

C - Mounting press

D - Lapping machine

F. Specimen cleaner F - Polishing machines

G - Metallograph

II – Hardness tester

1 – Diamond dispenser

1 - Etching device

K - Windows

L - Steel door

Metallography of Highly Radioactive Materials

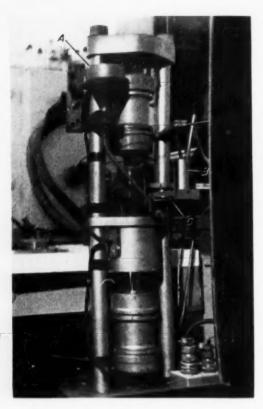
THE STUDY of the effects of irradiation on metals is an important phase of the work on nuclear reactors. When materials have been exposed to neutron irradiation, the metallographer is confronted with the problem of preparing and examining highly radioactive samples. Such work requires a remotely operated "hot" metallographic laboratory; it must provide shielding for protection of personnel, as well as facilities to confine air contamination and radioactive wastes.

The remote metallographic section of the solid state division began operation in November 1952. The general techniques used in sample preparation do not differ greatly from standard laboratory procedures, despite the complete loss of individual control in exercising the skills of metallography.

All of the metallographic equipment is housed in an area roughly 6x10 ft. The area is enclosed by 3 ft. of heavy aggregate concrete on all sides. Two 32x38-in, windows, 36 in, thick, and a 6-in, thick steel door provide

by M. J. FELDMAN Solid State Division Oak Ridge National Laboratory Oak Ridge, Tenn.*

*Valuable assistance has been rendered by Albert F. Zulliger of the engineering department of Oak Ridge National Laboratory and Robert J. Gray of the metallurgy division, who worked on the original design of the polishing machines; by Stewart Dismuke of the solid state division for help in cut-off wheel design and Brice Kinyon of the engineering department who designed the specimen cleaner.



means for servicing and viewing the operation. A rectilinear electric manipulator provides the "hand" necessary for transferring from one step to another. An overhead view of the cell is shown in Fig. 1.

The samples are sectioned for examination on the remote cut-off wheel shown at B in Fig. I. This operation has three purposes: (a) The area of greatest interest is exposed for examination; (b) the amount of radioactive material to be handled is reduced to a minimum; and (c) the surface imparted to the sample by the wet cutting wheel does not require any belt or disk sanding to prepare it for the initial polishing operation. All operating parts of the machine are enclosed so as to control contamination and also to facilitate recovery processes. Cutting speed is controllable, a sump provides for water-cooled cutting, and variable vise pressures can handle a range of sample types. Samples larger than 112x15 in. cannot be handled on the cut-off wheel and are sectioned in an adjoining cell that houses a "remote machine shop".

When a metallographic sample has been cut it is transferred to the remote mounting press shown in Fig. 2 (C of Fig. 1), placed on the lower mounting cylinder, and lowered into the

Fig. 2 - Remote Mounting Press

 $A-Revolving\ funnel$

B - Standpipe for washers

C - Transfer arm

heating chamber. A predetermined amount of bakelite powder is added to the mounting chamber by the manipulator through the revolving funnel (A in Fig. 2). The preweighed bakelite powder controls the height of the mount to 0.750 in. ± 0.1 in. This tolerance is necessary for uniform sample height in subsequent operations. A 15/16-in. identification washer of soft steel is also permanently mounted on the upper face of the mount. The washers are stamped with an identifying number and stacked in the standpipe (B in Fig. 2). They are remotely attached to the magnetized face of the upper piston by a transfer arm (C). Because of the critical dimension restrictions placed on the diameter of the bakelite mounts (±0.001 in.), they are cooled 25° C. under pressure.

Green bakelite powder was found to provide the most stable dimensions of the various

mounting powders available.

The mounted samples are then placed in a 12-in. "Crane Lapmaster" (D in Fig. 1) for rough polishing. This commercial lapping machine required a minimum of physical alteration to render it usable in the cell. The samples are held in individual weights by a permanent magnet which attaches itself to the soft steel identifying disk, 800-mesh alumina is fed automatically to the lapping plate by the machine. Usual lapping time is 20 to 30 min. On samples that have been sectioned elsewhere and are therefore not as smooth as those produced on the cut-off wheel the lapping time may become very long. For very rough samples that cannot be resurfaced on the cut-off wheel, the milling machine in the remote machine shop can be equipped to surface-grind mounted specimens. A magnetic chuck is used to hold the bakelite mount. (Here, as throughout the process, the soft steel identifying disk serves as a means for gripping the mount magnetically.)

When the samples have been lapped sufficiently they are transferred individually to the specimen cleaner (E in Fig. 1). The cleaner is one of the most critical steps in the polishing procedure and is unique even in remote work. While cleanliness of sample is always stressed in a metallographic laboratory, no special precautions other than clean hands and a clean source of solvent are necessary. In remote handling the problem becomes much more

complex. While the apparatus shown in Fig. 3 appears mechanically complex, it is really a compact collection of simple mechanisms. The loading clamps (A in Fig. 3) hold the sample while the manipulator removes the magnetic holder used in the lapping stage. These clamps then move the sample past a rotating brush (B) and over to the rotating magnetic grip (C), release, and move back to their original positions. With the grip rotating at 200 rpm., two sprays of solvent (D) cleanse the sides and surface of the specimen. Then a high-velocity jet (E) of "Eng-Sol" solution traverses the sample face while the magnetic grip increases its rotational speed to 1800 rpm. On the return traverse of the high-velocity jet. the solution flow is stopped and a jet of heated, filtered air dries the sample. When the jet has returned to its original position, the unloading clamps (F) move in, grip the sample and remove it for manipulation to the next stage. The cleaning cycle is so controlled from the panel that any of the three major steps

can be stopped at will or repeated if necessary. Each sample passes through the cleaning cycle four separate times during the complete prepar-

ation process.

After the lapping compound is cleaned off the sample enters the standard polishing stages. Three standard Buehler low-speed polishing wheels (F in Fig. 1) have been modified for this purpose. The three polishing stages are distinguished by the particle size of the dia-

mond polishing medium used. The first stage uses 6 to 12-micron diamond on a cloth wheel, the second 1 to 6-micron on a lead lap, and the third 0 to 1-micron diamond on a cloth.

A modified polishing wheel is shown in Fig. 4. The cover plate (A) houses solvent tubes (B)

Fig. 4 - Polishing Wheel Modified for Mechanical Manipulation

A - Cover plate

B - Solvent tubes

C - Window

D - Bearing for turret

E - Specimen turret

E'-Gear for specimen turret

F - Specimen holders

G-Sample

H - Cap for specimen holder

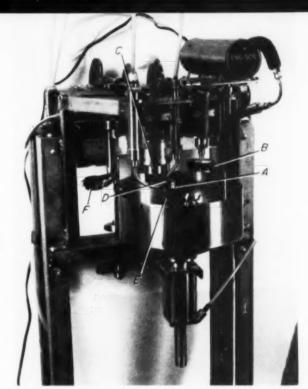


Fig. 3 - Special Specimen Cleaning Equipment

 $A-Loading\ clamps$

D - Cleaning sprays

B - Circular brush
C - Rotating magnetic grip

E — High-velocity jet F — Unloading clamps

used in flushing the wheels, a window (C) and the bearing for the specimen turret (D). The turret (E) is revolved in a direction counter to the rotation of the polishing wheel by means of a gear at E'.

Specimen holders (F) have a permanent magnet at their lower end to hold the sample (G), and are hollow so they can abe weighted with lead; their caps (H) are so designed that a permanent arm placed on the cover plate



"Hot" Metallography at Oak Ridge

will impart a quarter turn to the sample per revolution of the turret. The sample rests freely on the polishing cloth and is held square to the cloth by virtue of a clearance of 0.001 in. between the hole and the specimen holder assembly. Lubricant suitable for diamond polishing is added through a controllable drip-type lubricator.

Diamond compound is added directly to the specimen face of the bakelite mount before it is inserted in the turret. The diamond dispenser shown in Fig. 5 and at I in Fig. 1 has removable caps (A) which swing back so the manipulator can hold the sample just above the dispensing tips. Air pressure forces a plunger in against the diamond paste and extrudes a short stream of paste onto the specimen surface. Under usual circumstances one addition of diamond paste to a wheel is suffi-

cient to last for one or two days of operation.

Polishing times vary in the different stages according to the material being polished. The second stage is a lead lap used extensively to maintain a flat surface to the edges on corrosion specimens. It may be bypassed in processing samples where some rounding of the edge can be tolerated.

When the sample has been cleaned after final polishing it is placed on the metallograph shown in Fig. 6 and 7. This is a standard Bausch & Lomb "GBILS" metallograph built into a lead wall. A 6-in. extender tube was placed between the ocular and the shutter, and the wall constructed around this tube. The metallograph is suspended on standard shock absorbers and enough clearance allowed between the wall and the metallograph (and its controls) to prevent vibrations from reaching the instrument. In addition to the fine focusing control, the coarse focusing and stage controls

were brought out of the cell mechanically (A in Fig. 7). Figure 6 inside the cell shows a tungsten arc source that has recently been replaced by a 300-watt zircon arc source. In Fig. 7 the ground glass viewing screen is shown outside the cell. At the right of the metallograph is a window made up of four 2-in. sheets of high-density glass. This window provides a convenient viewing port for manipulating samples to the Lapmaster and the metallograph.

If the sample appears to be properly polished it is transferred from the metallograph to the etching manipulator shown in Fig. 8 (J in Fig. 1). Simple vertical and horizontal motions are provided by the train (A). The sample is picked up from the positioning track (B) by a permanent magnet (C), immersed in etching solution (D), washed in a fountain of water (E), dipped in alcohol (F) and finally dried by a heated air stream (G).

Etching is the stage of remote preparation that provides the greatest difficulties. This is na-

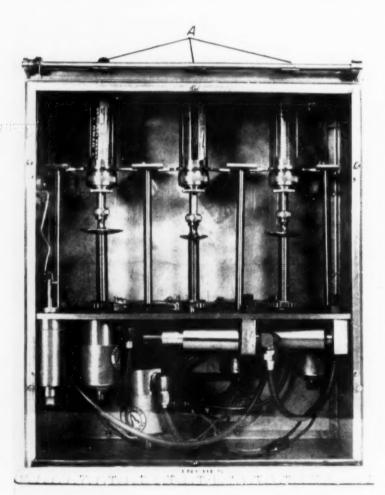


Fig. 5 – Diamond Dispenser. Removable caps shown at A

tural since it is in etching procedures that the metallographer must exercise considerable skill. Many standard etching procedures do not lend themselves to remote work. Often the time necessary to manipulate the sample from the etchant to the wash fountain is longer than the usual time of etching. In some instances the concentration of the etchant can be changed successfully, but many times a change in concentration means an undesirable change in etching characteristics.

Staining also presents a rather complex problem. Consistent production of stain-free specimens is difficult when the sample is generally not viewed from the time of its final polish until it has been etched and dried. However, stains are not an insurmountable difficulty. In the first place, they do not always mask the information we are seeking, and if they do, steps can be taken to overcome them. Because of the long time consumed in preparing metallographic samples by remote control and because there is always available a large backlog

of work to be done, the criterion for determining whether a sample is acceptably prepared must be based on the information desired from that sample. Our product is often comparable to that of a "cold" metallographic laboratory. In all of our work, processing is repeated until the experimental questions can be answered. A few scratches or slight stains that in no way detract from the validity of the photographable information are often tolerated.

At the present time we are using a batch process; a batch consists of the samples contained in four bakelite mounts. Actual working time from cutting to photography is two days. Total time, including preparation, transfer time, decontamination and clean up, is about one week.

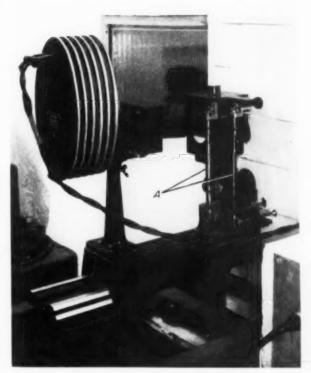


Fig. 6 – Portion of Metallograph Inside the Cell Showing Tungsten Are Source

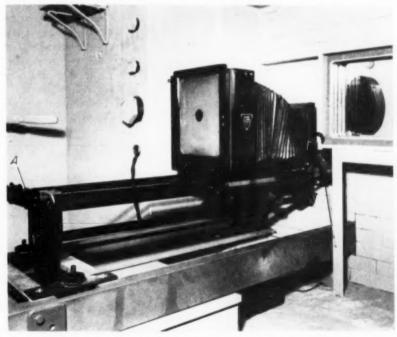
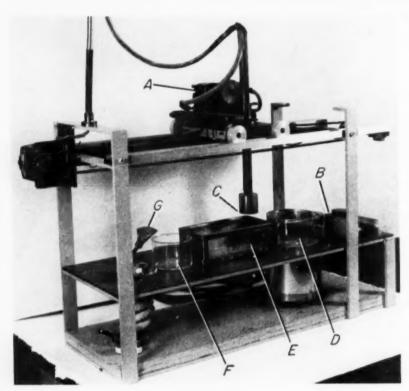


Fig. 7 — Outside the Cell Are the Ground Glass Viewing Screen of the Metallograph, and the Fine Focusing, Coarse Focusing and Stage Controls at A. The observer is protected by a wall of lead bricks. Window is four 2-in, sheets of high-density glass



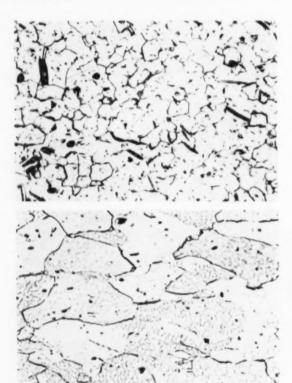


Fig. 9 – Specimens of Titanium (Top) and Tungsten (Bottom) Photographed by Remote Control. 250×

Fig. 8 - Etching Manipulator

A – Train device for moving specimen

B - Positioning track

 $C-Permanent\ magnet$

D - Etching solution

E - Fountain of water F - Alcohol bath

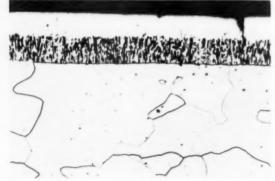
G - Air stream

The remote mechanical polishing equipment that has been developed will handle a wide range of materials. We have developed procedures for preparing samples of mild and high-carbon steel. Types 310, 316, and 347 stainless. copper, 2S and 24S-1 aluminum, molybdenum, tungsten, brass and Inconel. Figures 9 and 10 show some typical micrographs which represent the capabilities of the system. (Because of the "classified" or secret nature of our work at Oak Ridge, very few of

the photomicrographs we have taken with this equipment can be published.)

While the installation and satisfactory operation of more-or-less conventional mechanical polishing equipment was considered to be our first problem, we have not passed up the obvious advantages in many situations of electrolytic polishing and etching. Equipment for this purpose is being developed — now that the original problem seems to be solved — and will be in operation in the near future.

Fig. 10 (Below) – Specimen of Molybdenum Having a Surface Layer of MoSi₂. Indicating That Little or no Rounding of Edges Occurs in This Equipment



Heat Treating

HEAT TREATING FURNACES used in steel mills come big, and one of the giants among them will be the one Drever Co. will install in the Coatesville, Pa. plant of Lukens Steel Co. for treating stainless steel plate. It will handle plates up to 2 in. thick, 130 in. wide and 20 ft. long. Over-all length of the line will be about 365 ft., being made up of a 50-ft. charge table, 202-ft. roller hearth furnace, 10-ft. transfer table, 42-ft. long 1000-ton quench press and a 50-ft. discharge table arranged to swing 90 for crane pick-up of the plates.

Temperature range will be 950 to 1950 F. Heat treating cycles will be variable from 10 min. to 12 hr. to accommodate the wide variety of stainless and other steel analyses for which the equipment is intended. Rated capacity is 13,250 tons per month for annealing of stainless steel. The furnace will be direct fired with combination natural gas or oil luminous flame burners. Temperature control will be proportioning and divided into 10 zones 20 ft. long. All conveyer rolls, furnace doors and swing mechanism for the discharge table will be controlled from a single station located adjacent to the quench press.

Finishing

A UNIQUE corrosion resistant coating which is claimed to impart the protective advantages of stainless steel to common ferrous compositions has been invented by Gerald J. Horvitz, technical director, New York Testing Laboratories, Inc.*

The new process employs phosphorus which, when alloyed with metallic constituents in fairly large percentages of the total composition, greatly reduces the melting point and increases the fluidity of the alloy combination. Thus, the melting point of nickel is brought from 2640 F. to about 1600° F., allowing application at moderate temperatures with good alloying and bonding to the base metal.

Basic materials for this process are nickel oxide and various phosphorus compounds which are applied much like a paint to the surface of the base metal to be treated. These materials are easily available and are of relatively low cost.

The mechanism of producing the alloy is one of reduction under heat whereby metallic nickel and phosphorus are produced. In this reduc-

Short Runs

tion, advantage is taken of the fact that aumonium acid phosphate salts decompose in a
reducing atmosphere at elevated temperatures
to form phosphine, water vapor, free ammonia,
hydrogen and nitrogen. Beducing gases, along
with liberated hydrogen, produce a metallized
form of nickel from the oxides. Simultaneously,
phosphine reacts with nickel oxide and nickel
to form metallic nickel phosphide. Since rather
small amounts of phosphorus alloyed with
nickel greatly reduce the melting point of the
combinations, there results a wettable and flowable coating at the temperature of the operation. The usual reducing temperature range is
(Continued on next page)

*Patent No. 2,633,631, issued April 7, 1953.

Welding

One of the country's largest aluminum foundries is now using Heliare welding to correct imperfect eastings. The castings some of which are for vital defense production, must pass rigid quality inspections. The foundry uses a special line for this reclamation work which is done quickly and economically, yet produces X-ray quality welds.

Usually the only preparation required is grinding, although preheating is used if the area to be welded is particularly large. After the necessary preparation, the welding is done with a Heliare torch using special rods ast by the foundry. Every weld is X-rayed before the easting is released for assembly. (Photo courtesy Linde Air Products Co.)



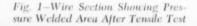
1550 to 1700° F. This is in the range of usual normalizing for steels and therefore will not cause excessive grain growth.

Where vessels are too large to be treated by a regular furnace operation, an alternate method comprises spraying of the nickel-phosphorus alloy directly to the surface to be treated. Advantage is then taken of the flowability and wetting properties of the alloy combination to produce proper bonding to the base metal. Induction heating or other suitable localized reduction heating methods can be used in the application.

Joining

THE METHOD of squeezing together two pieces of metal to form a strong joint, a technique being used for a number of applications in England where it originated, is now available in this country. In this process, called pressure or cold welding, ductile metals are joined by forcing together faying surfaces under a pressure great enough to cause considerable displacement of metal. The bond (shown in Fig. 1) resulting from the intermolecular flow of metal is reported to have a tensile strength greater than that of the parent wire.

A hand tool, made by Utica Drop Forge & Tool Corp. for Koldweld Corp. (the licensee in this country for this process), is shown in Fig. 2. The wire ends are placed in the holes of the dies on top of the tool, brought into correct position by adjusting the knob on the right, and the handles are then squeezed to make the





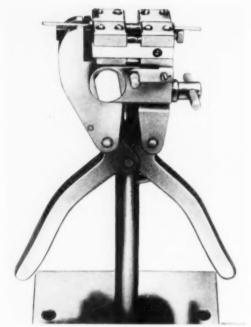


Fig. 2-Hand Tool for Butt Welding Wires by the Pressure Method

weld. In addition to its use for the butt welding of wire, the Koldweld process, as it is called, can be used to join flat strips of nonferrous metals, using another special tool.

Grinding

Thousands of Dollars in Diamonds Are Saved With Cloth Sack Tied to Pipe Bleeding off Coolant and Sludge From Grinder at the Carboloy Dept. of General Electric Co., Detroit



Advertisement

ELECTROMET Data Sheet

A Digest of the Production, Properties, and Uses of Steels and Other Metals

Published by Electro Metallurgical Company, a Division of Union Carbide and Carbon Corporation, 30 East 42nd Street, New York 17, N. Y.-In Canada: Electro Metallurgical Company of Canada, Limited, Welland, Ontario

High-Chromium, High-Carbon Iron

. . . the Iron That Hardens as it Wears

In many applications involving extreme abrasion, ordinary work-hardening alloys are not suitable. This is because most of these alloys require a definite pounding action for a martensite transformation, and the scouring action of an abrasive is not sufficient for development of high wear resistance. For this reason, high-chromium, high-carbon itons were developed — irons that wear-harden.

Chromium Content of Irons Ranges from 24 to 30 Per Cent

These irons are made in the electric furnace and have the following composition range:

Chromium	26 to 28	per cent
Carbon		
Manganese		
Silicon	.0.25 to 0.75	per cent
Sulphur	max. 0.05	per cent
Phosphorus		
Nickel		inimum
Iron		balance

Irons of this composition are readily castable by steel casting techniques.

Development of Greater Wear Resistance by Heat Treatment

Structurally, these irons consist of primary iron-chromium carbides in a matrix of iron-chromium solid solution and secondary iron chromium carbides. They are hard in the as-cast condition (500 to 550 Brinell). but when they are given an austenitization heat-treatment they develop much higher hardness (about 600 Brinell), and also have greatly improved wear resistance. Austenitization consists of heating these irons to a temperature of about 2012 deg. F. for an hour, then allowing them to cool in air. This heat-treatment promotes the formation of very unstable austenite-austenite that will transform to a harder martensitic endproduct even under rubbing or mild impingement action. Austenitization has been found to be far more effective in increasing wear resistance than the promotion of unstable austenite by the addition of ferriteforming alloving elements.

High-chromium, high-carbon irons can also be annealed to sufficiently low-hardness values for grinding or simple machining. Hardnesses as low as 350 to 450 Brinell can be obtained by heating the castings to temperatures of 1400 to 1450 deg. F. for 12 to 24 hours, then allowing them to cool in air.

Irons Have Wear Resistance Many Times That of Other Alloys

Austenitized high-chromium irons have been known to last as much as 21 times longer than other wear resistant alloys in applications involving extreme frictional abrasion. These applications include sand blast nozzles and liners, pantograph contact shoes, grinding disks, pulleys, chuteliner plates, dredge-pump liners, and rollers for crushing various hard materials.

In a recent test, high chromium iron was compared to special wear resistant steel cast ings as the material for hammers in a machine that was used to crush abrasive ma-



Fig. 1. After crushing the same amount of abrasive material in a hammer mill, the badly worn steel casting (left) had a weight loss of 37 per cent while the high-chromium iron casting (right) lost only 5,5 per cent.



Fig. 2. This chrome iron pantograph shoe had a service life of about 10 years. A tool steel that was used in similar service wore out in about 3 or 4 months; copper lasted about 24 hours.

terial. The chrome iron hammers were found to have almost 7 times the wear resistance of the steel castings.

When thoroughly backed up with zine, the iron also has enough shock resistance to be used effectively as crushing hammers and jaw plates for many severe rockhandling jobs.

Metallurgical Service Available

For years, ELECTRONIET high carbon ferrochrome has been used to make chromium additions to abrasion resistant high-chromium irons. If you should have any questions about either the production or use of these irons, write to the nearest ELECTRO-MET office. Our metallurgists will be glad to give many valuable suggestions and recommendations on how to make or use this iron most effectively.

Write for a free copy of the Fixernomer publication, "Abrasion Resistant High Chro-



mium Iron." This booklet is a collection of some of the best available information on how to make and to use abrasion resistant iron castings most efficiently.

The term "Electronet" is a registered trademark of Union Carbide and Carbon Corporation.

Correspondence

Gas Mixtures for Carbo-Nitriding

ROCKFORD ILL

We are very much interested in the article "Structures and Properties of Some Carbo-Nitrided Cases" in the June 1953 issue of Metal Progress. This article presented data on carbonitriding which was very much needed. However, we would like to make a few comments on the gas flows used, since these differ considerably from our carbo-nitriding practice.

The dual aim of carbo-nitriding is (a) to build up the carbon on the surface of the steel and (b) introduce enough nitrogen into its case to increase the hardenability so that sufficient hardness is obtained by a mild quench. The carbon is supplied to the steel by a carrier gas together with an enrichment gas (such as natural or propane) and the nitrogen is supplied by ammonia. Our gas flows and the flows used by Mr. Valentine (for oil quench only) are compared below.

Constituent	IPSE	NLAB	VALENTINE
GASES	MAX.	MIN.	
Carrier	89,5%	96.5%	76.5%
Natural	-3	3.2	5.6*
Ammonia	7.5	0.3	17.9

*Equivalent to approximately 11% natural gas.

This difference in practice is further accentuated by the fact that the ratio of natural gas to propane, when a change is made from one to the other, is 2 to 1. We have found that an excess of ammonia or enrichment gas will cause a poor microstructure of the case, resulting in free carbides and excessive retained austenite. It is even possible to form complex iron-nitrogen-carbon compounds with an excess of ammonia. It is our belief that the seemingly better results for the cyanided test bars and the dark etching constituents in the carbo-nitrided test bars might be due to the large amount of ammonia and propane used.

The types of cases that can be produced by carbo-nitriding are many and varied due to the availability of an additional element (nitrogen), and its effect apparently is nearly as great as that of the carbon content in carbonizing.

Frank Hobbs General Manager Ipsenlab of Rockford, Inc.

Patents Under the Atomic Energy Act

MADIERA BEACH, FLA.

The review of the A. S. T. M. Symposium on Radio-isotopes in the September Issue of Metal Progress fails to make clear the distinction between ordinary patents and patents coming under the 1946 Atomic Energy Act classification. Section 11b "Patents and Inventions" of the Atomic Energy Act takes precedence and supersedes other actions or laws, thereby allowing use of such patents on the research and development level. This is very important to industry for two reasons. First, this is contrary to normal patent rights, and second, most of the present radio-isotope uses are exploratory and would come under the newer interpretation of Section 11b. Consultation with patent attorneys is recommended if use of patented radio-isotope processes is contemplated.

> DON M. McCurcheon Consultant in Engineering-Physics

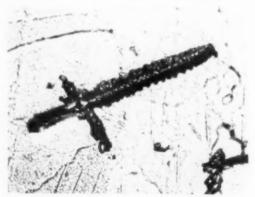
Sword of Science?

AMES. IOWA

The micrograph seems to have disclosed Will Burnett's "double-edged sword of science". Appropriately, it was found in a piece uranium.

This oxide inclusion appeared in a sample of alpha uranium, etched cathodically.

E. J. MANTHOS Metallographer HOWARD L. LIVINGSTON Metallurgist Ames Laboratory Iowa State College



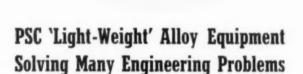
(More Correspondence on p. 108)



1/4 MILE of PSC ANNEALING DUCT

in Steel Plant of





This installation of PSC alloy duct for continuous annealing of strip steel is another example of how PSC "thin wall" construction is helping solve present-day engineering problems. Installed in the Indiana Harbor plant of Inland Steel Company, the system represents advanced designing in heat treating methods.

PSC "thin wall" construction effects hitherto impossible compactness and removability. It also introduces large economies in many types of construction, due to the savings in metal and to the lower fabricating and installation costs. Specializing in the precision fabrication of the weight-saving sheet alloys, PSC furnishes coils, ducts, flumes, manifolds, muffles and tubing for every heat and corrosion-resistant requirement; also tubes for radiant furnaces, and for furnace externals such as vent stacks. In any size and alloy.

Continuous strip steel annealing system at the Inland Steel Company plant, designed and built by Inland and Selas Corp. of America. PSC annealing ducts in black at top.







THE PRESSED STEEL COMPANY
of WILKES BARRE, PENNSYLVANIA

Industrial Equipment of Heat and Corrosion Resistant WEIGHT-SAVING Sheet Alloys

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Adapting the B & L Balphot for Eberbach Tests

INDIANAPOLIS

The Eberbach microhardness tester cannot be used directly on the Bausch & Lomb Balphot metallograph because its height is greater than that of the objective. However, the microscope can be adapted for the Eberbach tester, and those who have this equipment may be interested in knowing that this adaptation was made by the following alterations:

1. Mounting the microhardness indenter in a standard Balphot objective handle.

2. Making a new stage plate which raises the specimens approximately 0.200 in. The exact clearance was obtained by trial and error, this clearance being the exact distance required for the application of indenter load by lowering the stage with the cam-elevating mechanism.

 Modifying a standard objective adapter to clevate the objective lens by approximately 0.200 in. to compensate for the raised stage plate. This provides focusing of the impression by lowering the stage with the cam-elevating mechanism.

This adaptation permits rapid examination of the impression simply by removing the indenter and inserting the objective lens. Figure 1 shows the new stage plate and microhardness tester in place on the metallograph; Fig. 2 shows the objective adapter in place of the microhardness tester.

A filar micrometer eyepiece is used to measure the diagonals of the impressions produced. Recalibration of the eyepiece is necessary because of the increased height of the objective. A dial indicator is used to measure the distance between impressions, particularly where a complete traverse across a specimen is made.

Drawings of the modified stage plates and

the objective adapter which we made probably would not be suitable for others since adjustment of the exact dimensions of the stage plates and objective adapter will depend on the exact over-all length of the particular Eberbach microhardness indenter involved.

DOROTHY B. HOLBROOK Laboratory Assistant C. O. Sundberg Research Metallurgist Diamond Chain Co., Inc.

Overheating Temperatures of Boron Steels

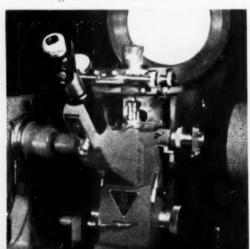
BETHLEHEM, PA.

In addition to the errors arising from your changing "heats" to "ingots" in the tabulated data and in Fig. 2 ("Effect of Boron on the Overheating Temperature of Steel," Metal Progress for August 1953), I note another rather serious error on page 83. I refer to your caption on the top of the page stating "Boron Steels Overheat Easily". The casual reader would be led to believe from this caption that all boron steels are prone to overheat at a low forging temperature, whereas it is clearly pointed out in the text and conclusions that the lowering of the overheating temperature occurs only with the boron steels made with the addition of 12% boron alloy.

Since boron steels have proved invaluable during the critical shortage of strategic alloys, it is regrettable that this misleading statement appears in the article. It is the author's thought that a correction should appear in one of the forthcoming issues of your magazine.

JOSEPH FIELD Metallurgical Supervisor Bethlehem Steel Co.

Fig. 2-New Stage Plate and Objective Adapter in Place on the Metallograph



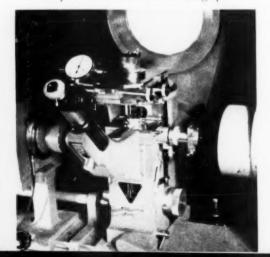
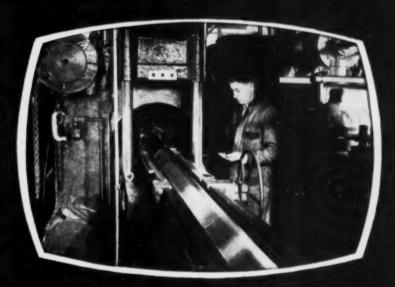


Fig. 1—Balphot Metallograph Equipped With New Stage Plate and Microhardness Tester





Here is a Lubricant that Can't Burn Off, Flake, or Gum Up



'dag' dispersions of colloidal graphite form microscopically thin dry lubricating films which fight friction beyond the burning-points of most oils. They cannot burn off, flake, or gum up at ordinary metalworking temperatures. These dry films are unaffected by heat up to 750°F.... under some conditions up to 3,000°F.

'dag' dispersions can profitably be used in stamping, deep drawing, piercing, casting, forging, stretch-forming, and wire drawing operations. They lessen die wear, produce smooth parting and clean surfaces, minimize scaling and sticking, reduce tearing and rippling, and assure uniform dimensions.

For more details on metalworking applications, write for Bulletin No. 426-10-L.

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Personal Mention



Bruce Chalmers

BRUCE CHALMERS (\$), who for the past five years has been professor of physical metallurgy at the University of Toronto, Canada, is now on the staff of Harvard University, Cambridge, Mass., as Gordon McKay professor of metallurgy. In addition to his duties there, Dr. Chalmers continues to act as editor of Acta Metallurgica (reviewed in the July 1953 issue of Metal Progress) and Progress in Metal Physics. Dr. Chalmers is a graduate of the University of London, England, in physics and later received his Ph.D. and D.Sc. also at London University. From 1932 to 1938 he was a lecturer in physics and mathematics at the same university, and from 1938 to 1940, he was on the staff at the Tin Research Institute as physicist. A term as senior experimental officer in the Ministry of Supply in London followed, and he later served as head of the metallurgy division of the Royal Aircraft Establishment in Farmborough, England. From 1946 to 1948. Dr. Chalmers held the position as head of the metallurgy division of the Atomic Energy Research Establishment at Harwell, going from there to the University of Toronto, Dr. Chalmers is the author of several books and numerous papers on physical metallurgy, and is a member of the Institute of Metals and the Iron and Steel Institute.



Harry A. Schwartz

HARRY A. SCHWARTZ , for many vears manager of research for National Malleable and Steel Castings Co., Cleveland, and a leading malleable iron metallurgist, has recently retired from full-time work. His services will be available to the company. however, in a newly created position of assistant to the vice-president in charge of production. Dr. Schwartz has been associated with National Malleable since 1902, and in 1912 established for the firm the first complete research department in the foundry industry. He is the author of "American Malleable Cast Iron" and "Foundry Science", and has often been honored for his contributions to the iron field, both in this country and in Europe. Dr. Schwartz holds honorary degrees from Case School of Applied Science (now Case Institute of Technology) and from Rose Polytechnic Institute, where he graduated in 1901. For his many technical and scientific contributions to the foundry industry. Dr. Schwartz was awarded the John A. Penton Gold Medal of the American Foundrymen's Association in 1930, and in 1939 received the E. J. Fox Gold Medal of the Institute of British Foundrymen, being the only American ever to receive that honor. He was named by the Malleable Founders Society for his outstanding contribution toward progress and

development in the malleable iron industry, and in 1951 was awarded the Charles H. McCrea Medal by his company.

Roy S. Kerns has retired from the Oxweld Railroad Service Division, Union Carbide and Carbon Corp., Chicago, as metallurgist and design engineer and moved to Phoenix, Ariz.

Richard Summers has resigned his position as metallurgist in charge of radiography at Bridgeport-Lycoming Division of Aveo Mfg. Corp., Stratford, Conn., to devote full time to the management of the newly organized Quality Control Co., Bridgeport, Conn. Mr. Summers holds the office of treasurer and technical director of the company.

J. B. Froblom has been appointed sales engineer for the James H. Knapp Co., Los Angeles.

John J. Stobie, Jr. , formerly sales engineer in the Chicago home plant of Apex Smelting Co., has been transferred to the company's new Los Angeles plant in a similar capacity.

J. Joseph Smith (a), manager of the locomotive division plant of the American Locomotive Co., Schenectady, since 1945, has been named manager of plant facilities for the company.

William J. Thomas has been appointed general manager of the tubular products division of the Babcock & Wilcox Co., Beaver Falls, Pa.

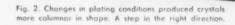
James H. Moore , formerly director of metallurgical research for National Research Corp., Cambridge, Mass., has been appointed general manager of Vacuum Metals Corp., a subsidiary of National Research Corp.

R. R. Hershey has been transferred from the Milwaukee office of the Timken Roller Bearing Co. to the Detroit office of the company.

D. Gardner Foulke has been appointed manager of electrochemical development of Hanson-Van Winkle-Munning Co., Matawan, N.J., and will be in charge of the laboratory phase of research and development work. Dr. Gardner was formerly chief chemist for the company.



Fig. 1, Photomicrograph of sheet with large irregular grains. Printing quality not up to par.



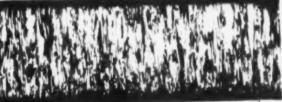


Fig. 3. Here is the structure that was found to give consistently good results. The copper deposit is of intermediate hardness and contains long, thin columnar crystals.

Copper, a basic and important requisite for the printing of Sunday magazines for metropolitan newspapers, has—since the introduction of rotogravure printing process in the United States—suffered from cylinder wear marks which have kept the industry puzzled, and often resulted in defective printing to such an extent that blemishes in printing were easily discernible to the eye—and although not too disfiguring, there remained the necessity for their elimination for the purpose of perfecting the gravure printing operation. In collaboration with a publisher, owner of one of the most modern plants in the world, Revere Copper and Brass solved this perplexing problem and is continuing to contribute to the technical improvement of the rotogravure printing process.

In preparing cylinders for printing roto sections, copper is plated on them before engraving. The electroplating of copper is rather an old process, and its techniques are well understood. By varying current density and composition of the solution, many different types of copper deposit can be obtained. But which of the various methods would give the best results in this case? Rather than engage in a lengthy process of trial and error, the publisher, who felt that the crystal structure of the deposited copper held the key, asked us if we would collaborate.

What Were the Crystals Like?

Sheets of copper resulting from different plating techniques were sent to Research, which not only made photomicrographs of the grain structure, but also determined tensile strength and hardness. As was expected, there were large variations. Some specimens had large and irregular crystals; in others, they were long and thin, like fibers standing on end. In tensile strength, the range was from about 31,000 to 56,000 p.s.i. Diamond Pyramid hardness numbers ran from 62.9 to 141.5.

Over a period of time five different sets of samples were submitted to the laboratory, which made detailed reports on each. By correlating these with his own records, the publisher was able to evaluate the effects of changes in plating techniques. The field of his investigation became narrower after each laboratory report, and in the end it was possible for him to obtain medium-hard, fine grain deposits which require little grinding and polishing. These results now are duplicated daily on a commercial basis. Today the publisher is noted for the exceptionally fine printing quality of his rotogravure sections. The newspaper is The Inquirer, Philadelphia, Pa.

If You Do Not Have a Laboratory

This is an outstanding example of the value of applied research. Many companies occasionally need information that can only be supplied by a laboratory, but are not justified in spending the large sums required to buy and maintain scientific equipment, and to employ qualified research personnel. These firms naturally seek outside sources of the data they require. Revere was glad to cooperate in this instance, because it produces large quantities of copper anodes for plating, and has both the equipment and the experience to make thorough tests of electro-deposited copper sheets or layers.

The Revere Research Department operates a laboratory that contains the latest scientific equipment, including the spectrograph and X-ray diffraction apparatus. If you feel the need of laboratory work on copper and its alloys, or aluminum alloys, please get in touch with the nearest Revere Sales Office.

REVERE COPPER AND BRASS INCORPORATED

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William E. Mahin has been appointed technical director of Vanadium Corp. of America and will direct the technical and research activities of the corporation. Mr. Mahin was formerly director of research for the Armour Research Foundation Chicago.

J. H. Hartwell (5), formerly product engineer for the Reed Roller Bit Co., Houston, Tex., is now vicepresident and plant manager for the newly formed Diamond Industrial Tool Co., Shreveport, La.

R. G. Nordstrom has resigned as manager of market development of the Torsion Balance Co., Clifton, N.J., to join the Ingersoll Products Division of the Borg Warner Corp., Chicago, as assistant to the president, and is in charge of new product research.

E. R. Freeman is now employed by Continental Can Co., Coffeyville, Kans., as supervisor and metallurgist of the quality control laboratory.

Andrew J. Griest, Jr. , who was formerly employed at Battelle Memorial Institute, Columbus, Ohio, as research metallurgist, is now in the metallurgy department at Lehigh University as project leader on fine powder permanent magnet research while completing work for a Ph.D.

H. J. Holquist has been appointed assistant manager of the cold finished bar division of Joseph T. Ryerson & Son, Inc., and will continue to make his headquarters in Chicago where he has been connected with the division in a sales capacity.

Jay DeEulis (a), formerly technical editor of the news bureau at the Carboloy Department of General Electric Co., Detroit, has been named manager of the bureau. Mr. DeEulis, who was at one time engineering editor of Steel, joined the Carboloy News Bureau in November 1952 shortly after his release from the Navy.

Eugene J. Schwetz has been recently transferred from the Chicago Works of National Malleable & Steel Castings Co. to its new subsidiary, the Capitol Foundry Co., Phoenix, Ariz., as chief metallurgist. Mr. Schwetz's former position was that of project metallurgist.

PRODUCT-

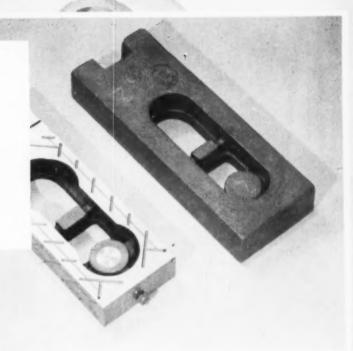
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So the radiographer checks each casting and discards the unsound.

For these radiographs he uses 220 ky at a distance of 40 inches, lead screens, and Kodak Industrial X-ray Film, Type K—the right choice for this thickness of iron and x-ray equipment.

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Whatever your radiographic problem, you'll find the best means of solving it in one of Kodak's four types of industrial x-ray film. This choice provides the means to check eastings and welds efficiently, offers optimum results with varying alloys, thicknesses and radiographic sources.

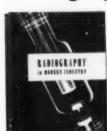
Type K — has medium contrast with high speed. Designed for gamma ray and x-ray work where highest possible speed is needed at available kilovoltage, without use of calcium tungstate screens.

Type A has high contrast and fine graininess with adequate speed for study of light alloys at low voltage and for examining heavy parts at intermediate and high voltages. Used direct or with lead-foil screens.

Type M provides maximum radiographic sensitivity, with direct exposure or lead-foil screens. It has extra-fine grain and, though speed is less than Type A, it is adequate for light alloys at average kilovoltages and for much millionand multi-million-volt work.

Type F provides the highest available speed and contrast when exposed with calcium tungstate intensifying screens. Has wide latitude with either x-rays or gamma rays when exposed directly or with lead screens.

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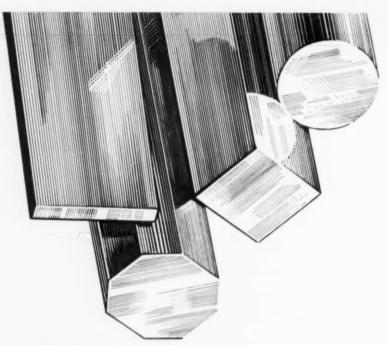
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Continuous Casting of Nonferrous Metals

THERE are two different methods of continuous casting - one whereby liquid metal is fed between cooled rolls (as suggested by Bessemer), and the other whereby liquid metal is poured into a cooled cylinder and a solid rod is withdrawn from the bottom. It is the principle of this latter method that forms the basis of the author's work.

An interesting suggestion is made to the effect that the continuous casting of titanium seems likely to be feasible along the lines presently developed for steel. Continuous casting may have two advantages, the one being an increased output over present methods and the other improved and more uniform quality.

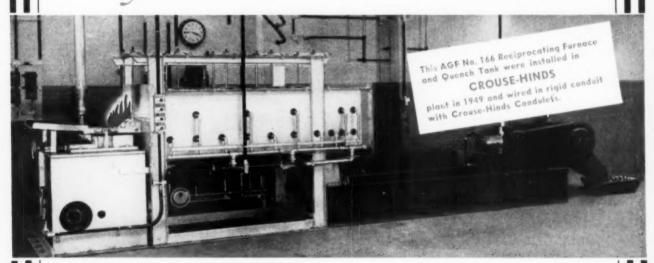
The author built a machine which, while not a duplicate of presentday commercial continuous casting plants, does, in his opinion, provide all the necessary facilities for his investigation. The 7-ft. high machine is capable of producing ingots of 1 in. diameter and at least 3 ft. in

Three kinds of melting units were employed: For lead, zinc and tin and the low melting point alloys, this was a carbon crucible heated by a ring gas burner. Aluminum was melted in an electric resistance furnace, the sillimanite pot being wound with "Kanthal" tape 0.125×0.01 in. in cross section and having a resistance of 0.579 ohm per ft. The carbon crucible used with this furnace was coated externally with alumina to reduce oxidation. Copper and cast iron were melted in a high-frequency furnace from which the molten metal was transferred for easting to an injector furnace provided with oxygenenriched firing. The approach of the author to the question of the size for the control orifice (0.1 in.) is typical of the general treatment of the whole investigation, namely the mathematical method.

The intent of the author in his (Continued on p. 116)

^{*}Digest of "Aspects of the Con-*Digest of "Aspects of the Continuous Casting of Nonferrous Metals", by B. H. C. Waters, Metal Treatment and Drop Forging, Vol. 19, September 1952, p. 379-384; October 1952, p. 474-478, 482; December 1952, p. 526-530, 532; Vol. 20, January 1953, p. 3-10, 20-22; February 1953, p. 79-83; March 1953, p. 103-109.

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"As a comparison, the operation was formerly done by heating in a salt bath in which both quantity and quality were unsatisfactory, requiring the services of an operator working under hard and undesirable conditions.

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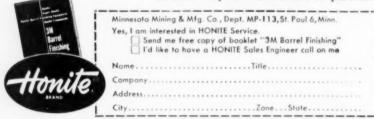
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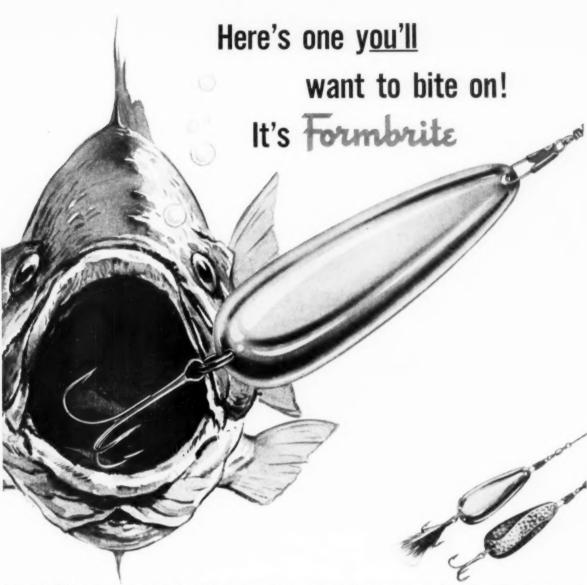
Continuous Casting of Nonferrous Metals

(Continued from p. 114) work is best expressed in his own words: "Naturally, various types of continuous easting processes have their own particular problems, and the work described in this series of articles is appropriate only to some of the problems of the casting process in which the metal is solidified in a cooled cylinder. It was carried out on a laboratory scale, and was undertaken to study aspects of the continuous casting process relating to the successful operation of the process and the properties of the metal cast. It has shown that the ease with which the continuous casting process can be carried out is interlinked with the physical properties of the metal being cast. No attempt was made at a systematic investigation of any particular industrial process; the work aimed rather at establishing principles involved in the continuous casting process in the light of which individual processes employed industrially could be considered."

Sketches and tables are given to show the principles involved in the design of furnaces and machines. It is stated that, in general, it is desirable that the crystal growth in a continuously east metal ingot should be, as far as possible, in a longitudinal direction. This requires a short mold with the water sprays placed close to the point of solidification of the metal. This removes much of the heat longitudinally. Such a method of cooling considerably restricts the amount of heat that can be removed in a given time and slows up production. The Asarco process operates on this principle for casting copper and bronze. Conversely, if faster operation is desired, cooling must take place in a predominantly radial direction. The mold length is increased and the result is a crystal growth more nearly radial. The Scovill process is an example of this.

The type of mold used in the author's experimental machine employs the radial cooling principle and the mold was nonreciprocating. The rate of cooling water was 500 gal. per hr., while the temperature rise was under 5° C. The ingot as it emerged from the casting mold was water sprayed. The steel liner was in

(Continued on p. 118)



Fish find this particular line of brass spinners so attractive that fishermen's demands have built annual sales of the Aeroplane Tackle Manufacturing Company of Denver to more than two million lures of all types.

The high finish on the spinner is part of the secret. While the cost of producing this is of no interest to the fish, it is to the manufacturer. Recently all brass orders were changed to Formbrite*, the superior ANACONDA Drawing Brass that has enabled this firm to cut polishing costs over 25%, and on several stamped products to produce the required finish by tum-

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Continuous Casting of Nonferrous Metals

(Continued from p. 116) slight tension in order to minimize the possibility of bulging. In the "conclusion" of the first section of these articles, the author states that it has been demonstrated that the experimental laboratory machine provides a tool with which an investigation of the production and properties of continuously cast metal ingots can be carried out. Other problems would doubtless develop in large-scale operation, but the results obtained by the small machine may, in many instances, be applied to commercial

The author next considers casting rate, mold surface and shape, and solidification rate. Also described are the different techniques used to continuously cast a variety of metals. Bottom pouring was used throughout and the usual degassing technique was employed. In the casting of lead and zinc, the stopper was removed and the molten metal allowed to run into a crucible placed beneath, until a steady flow was obtained. Then the crucible was removed and the metal flowed directly into the casting mold. Just after the metal began to enter the casting mold the downward movement of the dummy ingot was started. This rate of motion was gradually increased and then adjusted to maintain the level of molten metal in the mold about 1 in. from its top. The ingot being cast was keyed into the dummy ingot by means of a screw. Throughout the casting process there was therefore a positive pull drawing the ingot down from the mold. As a matter of fact, the ingot fell down from the mold under its own weight after the first part of it

Aluminum — It was not possible to continuously cast aluminum rod as a completely routine matter.

Copper – The process employed closely followed the method of Pell-Walpole and Kondic. The orifice for copper was 0.089 in. in diameter, accurately drilled and with the edges of the hole quite square.

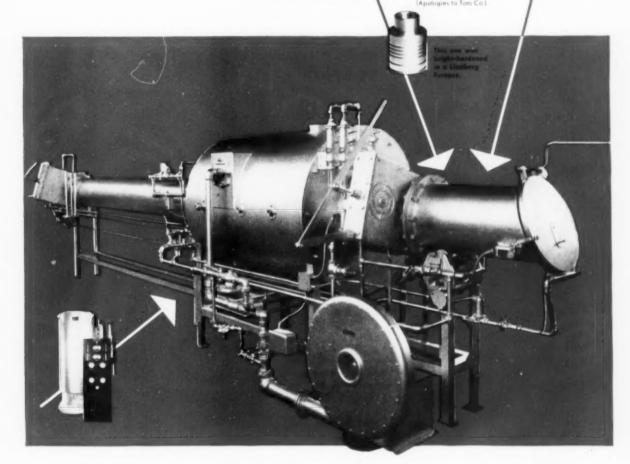
Cast Iron – The water jets for cooling were replaced by nitrogen jets directed upward to prevent thermal shock.

Steel - Only short ingots were (Continued on p. 120)

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If your production requirements call for the bright heat treating of stainless steel, completely free from oxidation and discoloration...you'll want to know more about this amazing Lindberg Stainless Steel Heat Treating Furnace, many of which have been in successful use throughout the country for 4 years. They are specifically designed for the heat treatment of stainless steels and other high alloy materials.

This process eliminates the need for operations such as pickling, sandblasting, and machining . . which are not only costly and time-consuming, but also often disturb the delicate balance of the

alloying elements on the surface of the metal.

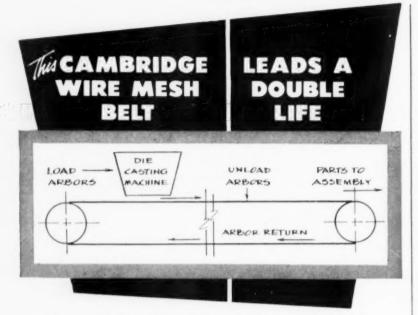
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Room air circulates freely through the open mesh of the belt to cool the castings. Hot castings cannot harm the allmetal belt. The moving belt feeds parts to the subsequent assembly line at a constant rate of speed.

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Continuous Casting of Nonferrous Metals

(Continued from p. 118)
cast owing to the metal overflowing
the mold in the casting process. The
ingot diameter was 2 in. as compared
with 1 in. for the other metals. A
larger orifice had to be used to avoid
solidification of metal at the rim.

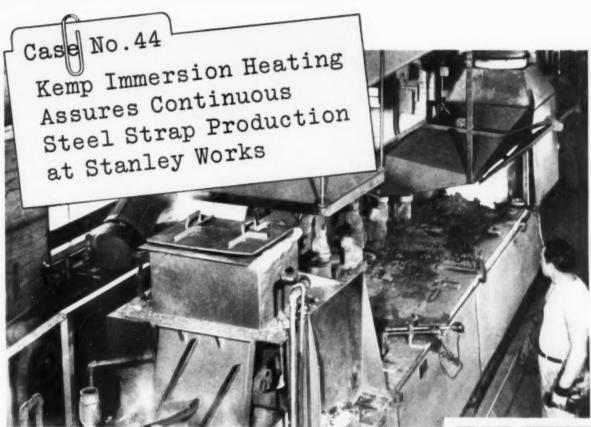
Bismuth Alloy — A eutectic alloy of 60% Sn, 40% Bi was cast so as to study the effects of its characteristic of expansion during freezing. A tapered mold was used and the casting was satisfactory.

The author goes on to deal with factors controlling permissible speed of casting, and attention is drawn to the fact that there is a maximum linear easting speed at which, using the conventional continuous casting arrangement, any particular alloy may be continuously cast. Because of the limited information concerning this, an investigation was made to find the factors and mechanism involved. Transverse fracture was found to be caused by: (a) the remelting of the first-formed solid metal skin as a result of heat being transferred to it from the interior metal; (b) definite tensile fracture of the metal skin.

In the course of the work, it was found that two types of fracture occur. In one type the fractured surface was visible and showed the characteristics associated with "hot tearing". The second was one in which the metal remaining in the mold flowed out after fracture. This caused a tube of metal to be left in the mold with the overflowed metal running out over the top of the fractured ingot. The first type was associated with a medium casting speed, while the second was found when last casting speeds were employed.

Transverse fracture of the ingot was invariably found when low melting point metals were cast using silicone grease as a lubricant. Such ingots showed a well-defined line at the middle point in the length of the ingot between a smooth and roughened surface. This would indicate that fracture was due to direct tensile breakage of the first formed outer metal skin. In the upper part feeding occurred by direct pouring of a static casting, but in the lower half the metal had been fed in

(Continued on p. 122)



How Stanley doubled steel strap capacity overnight...slashed fuel costs, too

Today this bustling division of the famous Stanley Works at New Britain, Conn., turns out steel strapping on a 24 hour basis. Starting with raw, high carbon steel on giant spools, strap is semi-annealed, finished, coated and rewound again for shipping in one continuous process. New rolls of raw steel are simply spot-welded to the ends of rolls to eliminate any interruption.

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From an output limited by the capacity of a gas underfired pot, production was doubled on the installation of a 32 ton Kemp Immersion Melting Pot. In addition, Kemp's greater heating surface, faster heat recovery, lower dross formation and accurate

temperature controls meant real savings in fuel costs. In the words of Mr. Harold Heckman, plant foreman, "Through quicker heating of this pot, we are able to maintain production schedules." And unlike underfired pots, Kemp units eliminate open flame hazards and excessive room temperatures:

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If you're dissatisfied with your present heating or melting equipment, consult Kemp first before you make any changes. Let Kemp Engineers show you how they can solve your tempering, annealing, descaling or coating problems quickly and easily. Then just like the Stanley Works, you'll be time and money ahead.



Rear view of Kemp Pot at Stanley Works shows gas feed lines, fire checks, and the Kemp Carbureter (left). Part of every Kemp installation, this carbureter assures complete combustion . . . without waste . . . without tinkering. Just set it, and forget it.

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furbishing your radiographic program, call your nearest Westinghouse X-ray office (listed in the catalog or your phone book). There you will find men of wide experience who can help you toward an efficient, modestly priced arrangement.

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Continuous Casting of Nonferrous Metals

(Continued from p. 120) gh a protecting solid met

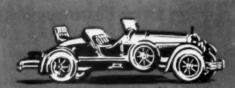
through a protecting solid metal aunulus giving a smooth surface. Some of the other ingots did not reveal the two zones until the surface was macro-etched.

Freezing Range - The freezing range of an alloy is a controlling factor as to its suitability for continuous casting. Fracture occurs when the ingot has been restrained by some cause at some point in the mold. Metal that shrinks away from the mold surface requires no lubricant. Pure metals are easier to cast than their alloys, most alloys being prone to hot shortness; for these a lubricant may be useful. Every lubricant does not work equally well with every alloy. For example, silicone is useful for aluminum, but when it was used for an alloy of 60% Sn and 40% Pb. continuous casting was impossible; vaseline provided a good lubricant for this alloy. Also, a nonlubricated mold is better than one improperly lubricated. Summing up the problem of lubrication, it may be said that for the slow casting speeds used for ingots of large section, and for the higher melting point metals, lubrication is not important; the chill contraction of the metal on hitting the mold surface is sufficient to give adequate mold-to-metal clearance. For higher casting speeds lubrication is important.

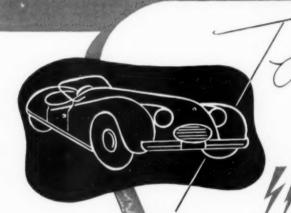
Hot Tearing - The metallurgical factors involved in hot tearing are: (a) the temperature range between the formation of the continuous network and the complete solidification of the alloy; (b) the strength of the continuous network; and (e) the ease with which the remaining liquid can feed between the primary constituents. It becomes evident, therefore, that the failure of a metal or alloy by transverse fracture during the continuous casting process is the result of the relationship of the ingot to mold clearance and the strength of the metal at high temperature.

Porosity – Density determinations and metallographic examination were used to determine the degree of porosity in the continuously cast ingots. This condition is considered as being due to a gas-metal type of reaction or to mechanical entrapment

(Continued on p. 124)



Other TIMES
Other METHODS...



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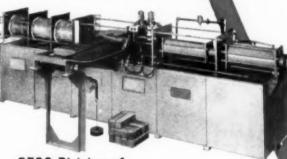
"Prior to the installation of Morrison-Geco dual frequency induction heating equipment, we used a fuel-fired furnace to heat billets prior to forging. The cost of fuel was 18.14° per billet. Now we heat billets at a cost of 8.15° per billet, on an 8½ hour shift per day. In addition to saving about 10° per billet, there is a saving of 1.73 pounds of steel per billet, which amounts to 12.85° per billet. There is also a further saving in personnel, since our induction heating installation requires 5 less operators than the fuel-fired furnace.

"Three fuel-fired furnaces were formerly used to heat shells prior to nosing. Cost of the fuel was 5.95¢ per shell, and the operation required a staff of six men. Using Morrison-Geco induction heating equipment, the cost of electricity is 4.25¢ per shell, with only four men required."

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CLEVELAND, OHIO Associate Companies: GENERAL ENGINEERING CO., LTD., TORONTO, CANADA BRITISH-GECO ENGINEERING CO., LTD., LONDON, ENGLAND - SOCIÉTÉ MANGIN, PARIS, FRANCE

TWO MILLION WITHOUT A FAILURE!

parts: small connecting rods

alloy: "600" series metal, a high strength bearing bronze that contains no tin

quantity to date: over 2,000,000

number of failures: none

forged by: Mueller Brass Co.

advantages: no bearing insert is necessary on either the wrist pin or crankshaft end because each rod acts as its own bearing. Dense homogeneous grain structure, close dimensional tolerances and high mechanical properties often permit redesigning for weight savings as high as 15% to 25%. "600" alloys have low coefficient of friction, high resistance to corrosion and tensile strength 2½ times greater than cast phosphor bronzes.

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METAL PROGRESS: PAGE 124

Continuous Casting of Nonferrous Metals

(Continued from p. 122) of gas and is closely associated with casting speed. It was found that casting rate also influences surface appearance and that better surfaces were obtained with higher rates. Detailed discussion is given of the "ripple" effect, and an attempt is made to correlate inter-ripple distance and linear casting speeds. The approach is largely mathematical.

The mass of detail contained in this report makes the abstracting of it difficult, and those directly interested are advised to consult the original articles. As one reads of the very numerous reactions involved in continuous casting one cannot but have admiration for those companies that, like Asarco and Scovill, are today turning out such large quantities of high-grade metal in various forms. It would be interesting if the author would do similar work on an alloy such as aluminum bronze which is forgeable at a high temperature, but forms aluminum oxide with celerity. H. J. ROAST

Oxides of Zirconium*

This progress report describes efforts to study the growth mechanisms of the corrosion products on zirconium. Cathodic sputtering of zirconium onto a buffed copper foil resulted in some contamination of the film. The difficulties were eliminated by thorough cleaning of the surface of the copper before sputtering, but because the copper could not be buffed smooth enough, electropolished copper was used. Two other base materials were tried, glass and collodion on a glass surface. The films could not be removed from glass surfaces and collodion tended to produce discontinuous films.

It has been observed that the appearance of the white film on zirconium changes from a tenacious film to a flaky white deposit. Since it was desired to make an X-ray study of the nature of these oxides, stand-

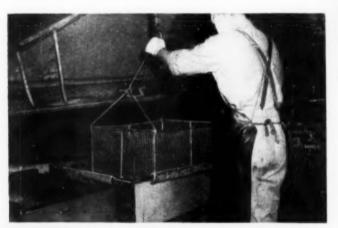
(Continued on p. 126)

*Digest of "The Corrosion of Zirconium", by L. E. Colteryahn, W. Joseph, W. E. Ray and H. J. Read, U.S.A.E.C. report NYO-837, available from the Office of Technical Services, Department of Commerce, Washington 25, D. C. Price 20 cents.

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Oxides of Zirconium

(Continued from p. 124) ands of the oxides first had to be prepared for comparison purposes because standard reference data were not available. Two different techniques for obtaining the oxides were used, precipitation with aumonium hydroxide and precipitation with sodium hydroxide. There was some indication that the oxide precipitated with ammonium hydroxide was a mixture of two different crystallographic structures. The oxides precipitated with sodium hydroxide

were identical to those formed on pure zirconium when heated in dry oxygen and closely resemble those formed by water vapor.

To obtain information concerning the effect of water vapor on the rate of formation of the zirconium dioxide, iodide zirconium was tested at 1110° F, for 5 hr, in dry oxygen and in water vapor. The dry oxygen produced a black film on one half of the specimen and a loose white oxide on the other half. The specimen heated in water vapor showed a thick white oxide film which was easily removed to reveal a gray sub-

surface. The weight increase of this specimen was more than 50 times greater than for the one heated in dry oxygen. These experiments indicate that the reaction occurs directly between zirconium and water rather than between the zirconium and the oxygen formed by the dissociation of the water. The authors state that a possible reason for the water vapor increasing the corrosion rate is that the dioxide initially formed possesses a defect structure which enhances the reaction with water. Experiments are planned to study the semiconductor properties of the oxide to learn more about the mechanism. The reviewer believes that the erratic results on the specimen heated in dry oxygen also indicate that heterogeneity of the iodide zirconium should be examined.

A. D. Schwoff

Corrosion Protection of Light Alloys*

The final results of an extensive series of outdoor exposure tests of some paint systems on aluminum and magnesium-base alloys and on steel are described. The various panels were exposed for 3½ years in marine, industrial and rural locations and to salt spray. Four different pigments were used in the primers, namely: zinc chromate, zinc tetroxychromate, iron oxide and red lead, with and without top coats.

At the marine station, the red lead primer, without top coats, showed considerable errosion; when top coats were used, there was crumbling of the entire film. Furthermore, red lead accelerated corrosion of the light alloys, particularly after the coating of red lead had begun to disintegrate from weathering. The iron oxide primer, without top coats, suffered marked chalking; this condition was prevented by the application of the top coat. It appeared to offer appreciable protection to aluminum alloys but little, if any, to magnesium allovs. Best protection to the light alloys was given by the zine chromate and zine tetroxychromate primers, the former being slightly preferable for use on the less (Continued on p. 128)

★Digest of "Priming Paints for Light Alloys", by J. G. Rigg and E. W. Skerrey, Journal of the Institute of Metals, Vol. 81, 1952-53, p. 481.



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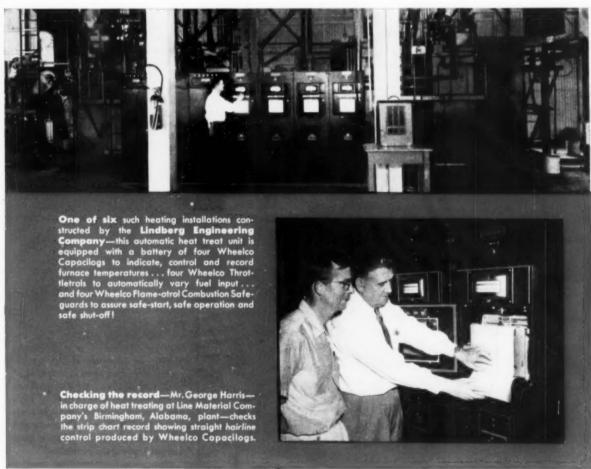
METAL PROGRESS; PAGE 126

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Carburized and hardened Speed Alloy mold, with hobbed cavities, made by W & L Molding Co., Kalamazoo, Mich. Note mirror finish.



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Corrosion Protection of light Alloys

(Continued from p. 126)

corrosion resistant alloys. The top coat of aluminum paint having an alkyd base was better than the pyroxylin-base material. Except with red lead systems, all the light alloys were superior to mild steel.

In the industrial location, red lead definitely accelerated corrosion of the light alloys before failure of the paint film. Red lead without a top coat ceased to protect mild steel after 12 months. Better results were obtained with top coats, but on the whole this system was inferior to those based on red oxide primers for the protection of light alloys. While the iron oxide primers were better, they failed to give protection without top coats; on steel, severe rust developed after 12 months. The addition of top coats gave considerable improvement. As at the marine station, zinc chromate and zinc tetroxychromate were better than iron oxide and red lead. either with or without top coats. With the exception of some erratic failure, systems employing these chromate primers gave satisfactory results. The light alloy specimens corroded much less than the steel specimens, whether painted or not.

Similar results were obtained in the rural location although, as might be expected, the extent of failure was somewhat less severe. The results in salt spray corresponded fairly closely to those in the marine atmosphere, although failure in salt spray was slightly less severe. This fact may be attributed to the greater severity of exposure at the marine station than had been anticipated.

At all test sites, definite evidence of acceleration of corrosion of light metal was observed with single coats of red lead, while zinc chromate and zinc tetroxychromate primers gave outstandingly good protection.

The general conclusions reached were: (a) that red lead primers should be avoided on light metal; (b) iron oxide primers are satisfactory where corrosive conditions are not too severe; (c) zinc chromate or zinc tetroxychromate primers should be used on light metals for the most severe corrosive conditions; and (d) alkyd vehicles are superior to pyroxylin for aluminum paint top coats.

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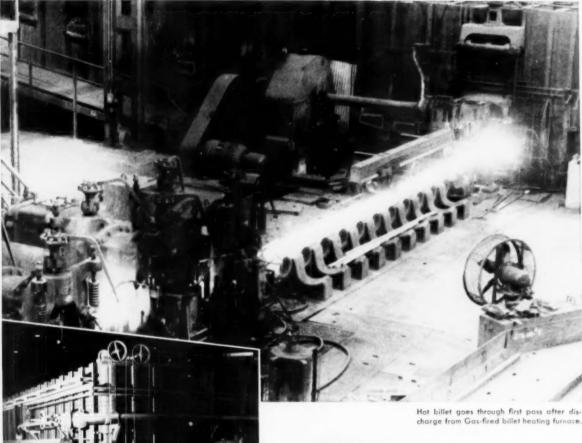
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Quality Control in Metal Processing*

PRINCIPLES are more persistent in time than is practice, and a good deal more reliable. The purpose of this paper is to outline some of the factors underlying control of quality and to reduce promising lines for future research and development.

The technical control of processes is not an end in itself. At any one time within a company there is an optimum standard quality for a prodnct. Control of quality in the region of this standard is economically desirable. Frequently schemes of instrumentation or recording are devised, apparently for their own sake, with only a vague and hopeful picture of how the quality or economy will be affected. Such a state is not regarded as control,

Quality has two separate, but not incompatible aspects. One concept regards quality as being measured on a scale leading to objective perfection without relation to uses or application. Second, quality may be linked to ultimate use, the criterion being fitness for purpose. In metallurgical manufacture the ideal standard is set by the intended purpose.

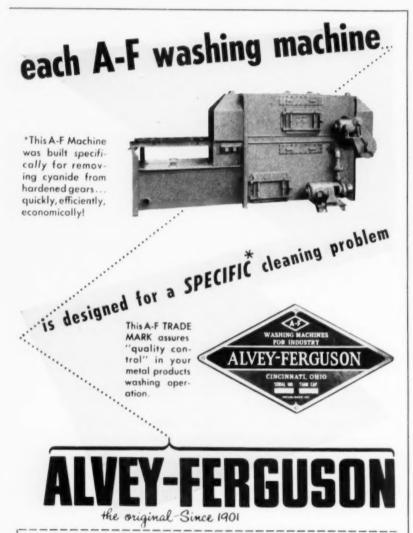
A simple example is a strip of metal produced for subsequent deep drawing. The quality of the strip is a function of its chemical composition, metallurgical structure and properties, surface condition, and its dimensions. All of these quantities (except surface) can be measured with precision and expressed numerically. If no method of physical measurement is available, the best that can be done is to establish standard examples and use them as guides for classifying the products on the basis of the judgment of the inspector. The best standard of quality for an individual article is the nearness of the strip to the standard expressed numerically. In case of a group of strips, the best measurement of quality is the mean and standard deviation of the dimension or quality characteristics of the individuals.

The cost of production is expected to rise steeply as the tolerances about the ideal dimension are narrowed, and will tend to level to a constant money value as tolerances are widened. This relation is termed the cost curve. The value to the customer is zero at some point just beyond the widest acceptance tolerance and usually flattens out as the ideal dimension is reached, so that narrower tolerances result in no increase in value. Foi all profitable production processes, the value curve and the cost curve intersect. The tolerance for optimum profit is at the point of greatest difference between value

For any process operating to fixed tolerances, there is an optimum rate of rejection which minimizes the cost of production per unit of acceptable product. Effort should be made to ascertain and then to attain this best rate of rejection rather than merely to attempt to decrease rejections to a minimum.

W. A. Shewhart's definition of control is used as a basis of further development: "A phenomenon is said to be controlled when, through the (Continued on p. 132)

★Digest of "The Principles of Technical Control in Metallurgical Manufacture", by A. R. E. Singer, Journal of the Institute of Metals, Vol. 81, March 1953, p. 329-340.



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Quality Control in Metal Processing

(Continued from p. 130) use of past experience, we can predict, at least within limits, how the phenomenon may be expected to vary in the future."

Uncontrolled processes will not continue of themselves to give a product of constant quality. Before process control is established, the causes of variation must be separated into assignable and random causes and the cause related to the effect. The next stage is to set up standards by defining the tolerance or limits within which the product may vary and yet remain acceptable.

The chief characteristics of four main methods of control are considered: automatic control, control by human operator, statistical control, and operational research. The particular feature of statistical control is the recognition of the part played by chance fluctuations in manufacturing operations leading to a procedure for dealing with them and for reaching definite conclusions despite their occurrence. Uncertainty is inherent in any data and is shown up clearly by, but is not derived from, a statistical analysis. The methods of operational research are not clearly described. Its broad objective, however, is commendable; this is to collect and analyze data obtained during manufacture or use of the product and to present the results as a basis for executive action.

It is concluded that advances in the control of quality will be made by extending technical control to cover more of the primary variables encountered in manufacture.

F. G. Norris

Four Approaches To the Study of Plasticity*

This paper was the 23rd Autumn Lecture of the Institute of Metals, presented at Oxford in September 1952. Professor Swift, from the University of Sheffield, is one of the outstanding engineers engaged in studies of metal forming processes. His unusual knowledge of industrial forming operations is supplemented by a keen insight into the nature of the physical process of slip within metal crystals, and by an understanding of mathematical analyses of macroscopie plastic flow processes. Among the attributes of the author is his unique ability to tell a complex story in an interesting and clear way. A quotation from the article will illustrate the lucid and humorous style of the presentation. In describing the technological skill involved in transforming a flat sheet of steel into an automobile fender in a single stroke of a press, the author says: "Neither the man who casually presses the button nor his mate who idly applies an oily rag at the right spot on the sheet has anything to learn from Charlie Chaplin in the matter of masterly nonchalance." The text is technically sound and cleverly written, with just enough humor injected at appropriate places to make the paper a pleasure to read.

The discussion of plastic properties (Continued on p. 134)

★Digest of "On the Foothills of the Plastic Range," by H. W. Swift, Journal of the Institute of Metals, Vol. 81, November 1952, p. 109-120.



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METAL PROGRESS: PAGE 132



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NOVEMBER 1953; PAGE 133

Four Approaches To the Study of Plasticity

(Continued from p. 132) is divided into four classifications—metallurgical, engineering, mathematical and physical—with the view-point of each being substantially different. The metallurgist and engineer are generally compelled to use empirical and trial-and-error methods; the metal physicist is concerned with developing an understanding of the nature and mechanism of plastic flow on an atomic scale; and the mathematician's interests in plasticity range from making analyses of be-

havior on an atomic scale to the macroscopic distribution of stresses and strains in a given material being formed in a specified manner.

The mathematician's approach is described, with historical references and developments being included for perspective. However, no complex or detailed analyses are included, because this paper was intended to describe the state of knowledge in a broad and general way. Enough examples are given, though, to show the present state of development.

The approach of the metal physicist is discussed, with the objectives of discovery of new materials, rationalization of predictions of the effects

of mechanical or heat treatments, and planning of test procedures for plastic properties along more basic lines. The metallurgist and physicist are treated somewhat roughly by the author: that is, in discussing space lattices and unit cells he says ". . . the engineer . . . is not accustomed to deal in astronomical reciprocals, and the microgeometry of the space lattice is based upon techniques which have to be seen to be disbelieved". In discussing the model of a dislocation he says ". . . . the nodulus networks of knock-kneed knobs in which the metal physicist is apt to enmesh his students".

The engineering approach to the problem is treated with due humility. The general problem of analyzing stresses and strains during even simple forming operations is still beyond the range of the theoretical plastician. A deep drawn cylindrical shell was chosen as an example for illustrating approximate methods for calculating stresses, strains and punch loads. Even though the methods are approximate, the theoretical values agree remarkably well with actual measurements.

This paper is one that everyone interested in plastic flow should read—and those who take the few minutes required to do so will find it thoroughly enjoyable. E. R. PARKER

Thermocouples for 3400° F. Temperatures*

DURING casting operations carried out in the Ames Laboratory as part of a program of study of highmelting metals and alloys, it was found necessary to measure with some degree of accuracy temperatures up to approximately 2000° C. (3630° F.). Because of the nature of the metals these operations had to be done in either vacuum or inert atmospheres. Radiation pyrometers were found to be unsatisfactory in this work due to evolution of gases which cut down light intensity, and to formation of deposits on the sight (Continued on p. 136)

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*Digest of "High-Temperature Thermocouples" by H. A. Wilhelm, H. J. Svec, A. I. Snow and A. H. Danne, United States Atomic Energy Commission report AECD-3275, available from the Office of Technical Services, Department of Commerce, Washington 25, D.C. Price 5 cents.

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Thermocouples for 3400° F. Temperatures

(Continued from p. 134) windows. An alternative method of measuring these temperatures was to use a thermocouple, but the usual "high-temperature"—thermocouples could not be used for the temperature range encountered in this work.

The tungsten-molybdenum thermocouple seemed to have considerable promise and was the first one investigated. The materials used were 16-mil tungsten and molybdenum wire obtained from the Callite Tungsten Corp. and doublebore beryllium oxide thermocouple insulators made in the Ames Laboratory. This thermocouple found considerable use in the high-temperature metallurgy of the laboratory, but since it possessed a very small emf. coefficient and reversed in sign in the region below 1500° C. (2730° F.), further studies were made to find a more suitable couple.

Couples were prepared from tantalum-molybdenum, tantalum-tungsten, columbium-molybdenum and columbium-tungsten for preliminary tests. Only the tantalum-tungsten and columbium-tungsten showed promise and calibrations were carried out ou them. The tantalum and columbium wire was obtained from the Fansteel Metallurgical Corp.

In general, calibration involved the comparison of the test couple with Pt-Pt. 10% Rh thermocouple up to 3050° F., followed by a checking of this curve against melting points of pure metals. Metals used to check the comparison calibrations were Ag, Cu, Au, Pd and Pt. Melting temperatures used for these standards were in the order of 960° C. (1760° F.), 1083 (1981), 1063 (1945), 1553 (2827) and 1773° C. (3223° F.), respectively. The Ag and Cu were used in massive form; the Au, Pd and Pt in wire form and calibrations with the latter group were carried out by making a connection between the two thermocouple wires with a short piece of wire so that the melting point was to be observed as the wire was heated slowly. It was found that values within 0.1 millivolt were readily reproduced. The points obtained in this way agreed well with the comparison calibration and in addition gave a calibration point at

(Continued on p. 138)

The Park Neutra-gas Story:

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Thermocouples for 3400° F. Temperatures

(Continued from p. 136)
1773° C. (3223° F.). Since heating to temperatures far above this point showed that no radical change in the nature of the curve for the Cb-W couple was evident, it was felt that the curve might safely be extrapolated to at least 1900° C. (3450° F.). Attempted calibration in the higher range using an optical

prometer was not reliable because the correction factors were unknown,

Calibration curves were obtained for several lots of Cb wire, all coupled with a single lot of W wire. One calibration was found to hold for each lot of wire within ± 25° C. (45° F.); however, the difference in calibration between separate lots in some cases amounted to as much as 100° C. This is rather difficult to explain since the different batches of columbium were of the same purity and had the same treatment.

The fact that tungsten recrystallizes at high temperatures and becomes very brittle is a serious drawback. Junctions cannot be welded because the thermocouple then cannot be moved without breaking. It was found that a satisfactory junction can be made by tightly twisting the more ductile columbium wire around the tungsten for several millimeters and then tightly pinching the two together. To re-use the couple, the brittle portion is broken off and a new junction formed.

The couple was used regularly for quite some time in the Ames Laboratory and in pilot-plant operations and, although it possesses serious faults compared to the conventional low-temperature thermocouple, it is the best found up to the present time for the temperature involved.

G. M. SINCLAIR

Quality Control in the Production of Magnesium Alloys for Hot Working*

It is interesting to note the emphasis that has been placed by the authors upon the importance of conscientiousness and experience in the production and control of quality in melting and casting magnesium alloys. Their presentation is complete and detailed. From it, with only a working knowledge of magnesium melting and handling, one should be able to achieve castings of good quality.

The close adherence in practice to the procedures described in this paper has provided a means to produce a material of very satisfactory quality, and has enabled them to maintain a rejection rate of less than 1% over a period of several years.

They melt the magnesium-aluminum-zine-manganese alloys and chilleast them into permanent "book" molds for extrusion and rolling ingot. High-stretch magnesium-zine-zirconium alloys are poured by the semicontinuous direct-chill process.

An unusually intensive quality control program is necessitated by the fact that they are producers of (Continued on p. 140)

*Digest of "The Control of Quality in Melting and Casting Magnesium Alloys for Hot Working", by R. G. Wilkinson and S. B. Hirst, Journal of the Institute of Metals, Vol. 81, March 1953, p. 393-400.



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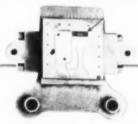






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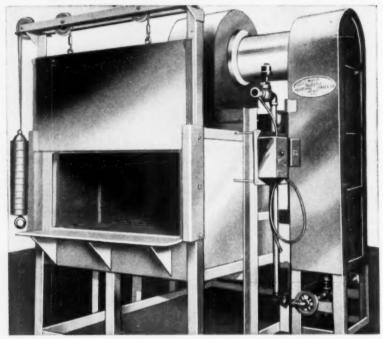
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Quality Control in the Production of Magnesium Alloys for Hot Working

(Continued from p. 138) extrusion and rolling ingot to be fabricated by other companies.

The magnesium-manganese and the magnesium-aluminum-zinc-manganese alloys are melted in 4000-lb. cast steel crucibles. Charges consist principally of cell magnesium, runaround scrap and some secondary ingot. Manganese is added as manganese chloride. Melting and refining operations are conducted under the protection of fluxes that are dyed for identification and designated by letter. Completely alloyed crucibles are transferred to tilting furnaces where they are held at 1380° F. This metal is then poured into 300lb. fabricated mild steel crucibles that are placed into gas-fired settings where they are flux-refined and the temperature of the melt increased to 1470° F. The melt is then cast into the mold. The mold is tilted to a position of 15° to the horizontal and is slowly raised to a vertical position during the casting operation. A hot top or top hat is used to supply feed-metal to the cooling casting.

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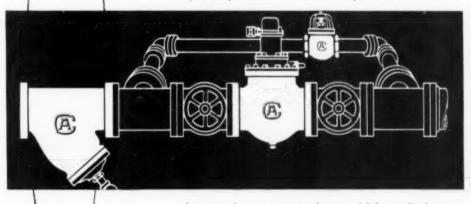
Meticulous compliance to a sound, conscientious program of melting, alloying, handling and casting is their method of controlling non-metallic inclusions and producing a reasonably uniform, fine-grained M alloy (AM 503).

It was learned while developing the magnesium-zirconium alloys that only an average product could be obtained if these alloys were cast into the conventional book-type mold. When these alloys were cast into book molds, there was incidence of outcropping microporosity resulting in internal oxidation and nitride formation during the prerolling soaking operation. The slow solidification rate of the book mold also contributed to the formation of zirconium segregation in the larger sized ingot.

In 1944 Magnesium Elektron Ltd. designed and constructed a small plant for direct-chill casting. Mag-(Continued on p. 142)



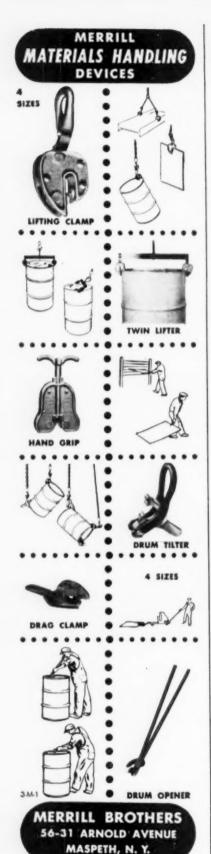
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Quality Control in the Production of Magnesium Alloys for Hot Working

(Continued from p. 140)
nesium-manganese and magnesiumaluminum-zinc-manganese alloys
were readily cast without difficulty
on the direct-chill unit. They then
decided to utilize the machine for
the production of the zirconiumcontaining alloys ZK 30 (ZW 3) and
ZK 10 (ZW 1).

Their direct-chill machine consists essentially of three units for pouring, controlling and casting of metal.

The 300-lb. melts are prepared from refined magnesium ingot, process scrap and zinc. Zirconium is added as "master salt." A special "HE" (dyed blue) flux is used for ZK (ZW) operations.

The melts are poured from the crucibles into the mold either from a reservoir for rolling slabs and large ingot or simply down a launder for the smaller ingot. A tundish or stilling plate supported in the center of the slab or large ingot molds distributes the metal poured from the reservoir.

The molds are water-cooled sleeves, cooled by water rings—the number of water rings depending upon the mold length. Additional cooling is applied to the cast as it emerges from the mold.

The castings are withdrawn by a double acting hydraulic ram.

The use of vibration on the mold was tried and discontinued when they found an interesting banded concentration of zirconium segregation and the associated β -phase in their casting.

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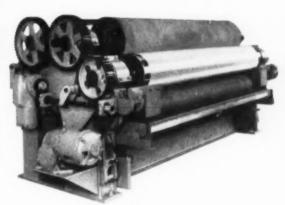
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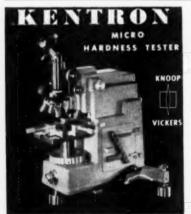
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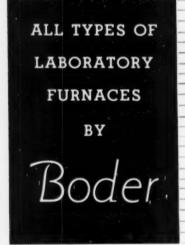


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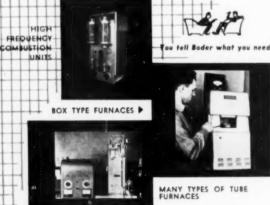
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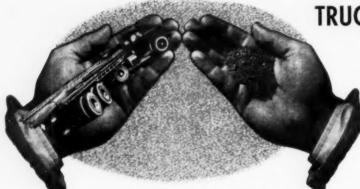


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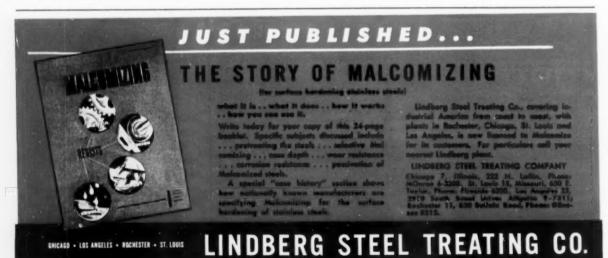
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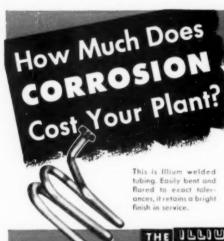
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giving complete details ELECTRIC MANUFACTURING CORP 30 SO. SHELBY ST. . INDIANAPOLIS. IND



LIST NO. BY ON INFO-COUPON PAGE 158

TOGETHER ---

TO GET THE HEAT TREATING CONTAINERS YOU WANT!



Tell Stanwood Engineers your particular problem—type of parts you are heat treating furnace capacity-cycle, etc. With our broad experience and production facilities we can supply baskets, trays, fixtures, carburizing boxes, retorts or furnace parts to exactly meet your needseconomically too! Send for literature.

Representatives in Principal Cities





Corporation



12 ON INFO COUPON PAGE 168

Upton

OFFERS

the most advanced Salt Bath Furnaces

FOR

BATCH TYPE WORK

CONVEYORIZED TYPE WORK

ALUMINUM BRAZING

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UPTON ELECTRIC FURNACE CO. 16808 Hamilton Avenue Detroit, Michigan

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IDUSTRIAL FUEL BURNING EQUIPMENT...

Designed FOR YOUR SPECIFIC REQUIREMENTS

- Motor-Mix Burners
- Model DA Mixers
- Western Safety Valves
- Injector-Mix Burners
- Flame Retention Nozzles
- Accessories
- Inspirator-Mix Burners
- Blowers
- · Multiport Burners
- Custom Built Equipment

Free descriptive literature on request

WESTERN PRODUCTS, Inc.

the QUENZINE STORY

Low priced, more readily available carbon steels can often replace alloy steels when quenched in Beacon Oils with Quenching QUENZINE added. For information on this new additive and **OUENZINE** STORY other Beacon Brand Heat Treating Com-pounds write to . . .



ALDRIDGE INDUSTRIAL OILS, Inc.

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CONTINUOUS



ATMOSPHERIC - RECIRCULATING -PUSHER-ROTARY HEARTH-CONVEYOR - RADIANT TUBE - POT CAR-BOTTOM- ALUMINUM REVERBS. "Tailored by Dempsey"



DEMPSEY INDUSTRIAL FURNACE CORP. Springfield 1, Mass.

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Fahrite is used for: Rails • Trays • Carburizing Boxes • Retorts • Solution Pots . Rollers • Muffles • Radiant Tubes •

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THE OHIO STEEL FOUNDRY CO.

many other products

Plants at Lima and Springfield, Ohio

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METAL PROGRESS: PAGE 150



SHERMAN INDUCTION HEATING EQUIPMENT



Megacycle Tube Type Machines

Soldering . Brazing . Bombarding Annealing . Hardening

Sizes: Standard-2,4,10,25 KVA; Custom-to 100 KVA

Fast . Powerful . Reliable

Challenge Comparison - Value • Quality • Price • Design • Appearance

Free Trial Run of Your Sample Parts Complete data, application photos, prices, delivery in New illustrated Catalog, Write

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Natural Gas at 1# to 30#

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BOX 729 CANTON, OHIO

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HEAT TREATING!

- **★** Carburizing Salts
- **Neutral Salts**
- * Tempering Salts

Faster more fluid baths!

Free washing!

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FURNACES

for Every Heat Treating Process

CONTROLLED **ATMOSPHERES**

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CIRC-AIR DRAW **FURNACES**

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(CARBONITRIDING)

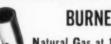
Specially Engineered for Your Particular Needs

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INDUSTRIAL HEATING EQUIPMENT COMPANY

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PULSATION-INSPIRATOR



for KILNS . HEAT TREATING

SWIFT BLACK!

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- ★ Uniformity of Blackening Guarantees Economy

Send for FREE Literature on Swift BLACK and Cleaning Compounds TODAY!

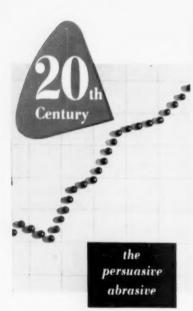
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With skill and ingenuey, NARACO engineers designed this fuse rack to answer the difficult problem of perfectly plating nozzles and ventricles. Need help? Call your NARACO office today.

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Production curves take on healthier look when you use 20th Century *Normalized shot, the persuasive abrasive. In daily use in foundries and metalworking plants everywhere, its high uniformity has proven it more efficient, more economical.

Try it in your plant!

THE CLEVELAND

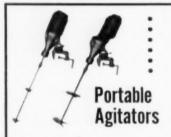


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One of the world's largest producers of quality that, grit and powder—Hard Iron—Malleable
'Normalized' Cut Wire—Cast Steel (Realsteel)

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Light weight, heavy duty models with swivel clamp. Available 1/4 to 3 HP sizes in three styles with either adjustable or rigid shafts.

Ideal for Quench Tanks, Salt Baths, Plating Tanks and Waste Treatment.

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Dayton 2, Ohio

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LIST NO. 75 ON INFO-COUPON PAGE 158



LIST NO. 10 ON INFO-COUPON PAGE 158





DANIELS PLATING BARREL & SUPPLY CO.

MANUFACTURERS and DISTRIBUTORS
Electropiating and Polishing Equipment and Supplies
129 Oliver Street, Newark S, N. J. + Tel. MArket 3-7450

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New multiple DANIELS PLATING BARREL unit designed to handle small lots of work economically. Individual removable tanks allow plater wide range of plating, pickling, or cleaning applications.

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HOW TO DO BRIGHT GOLD PLATING

without scratch brushing or buffing!

GOLD

SILVER

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Write for complete details



FOR INDUSTRIAL and DECORATIVE USES

- Exceptionally hard deposits twice the hardness of conventional gold plating.
- Operates at room temperature quires absolute minimum control.
- Excellent metal distribution and throwing power.

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Dept. BB, 229 Main Street Belleville 9, N. J.

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WELDCO FABRICATED MONEL PICKLING EQUIPMENT

- Hairpin Hooks
 Sheet Crates
 - · Steam Jets · Chain
- · Mechanical Bar, Tube and Coil Picklers

THE YOUNGSTOWN WELDING & ENGINEERING CO. 3728 OAKWOOD AVENUE . YOUNGSTOWN 9, OHIO

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BASKETS

industrial requirements

for de-greasing - pickling anodizing — plating materials handling small-parts storage

of any size and shape any ductile metal

by

THE C. D.



MFG. CORP. 28 Pequot Road Southport, Conn.

Dudlike "Gives our tools Sales Appeal"



BARNABY MFG. CO. of Bridgeport, Conn., reports: "Our close proximity to salt water has given us problems in rust prevention for many years. We have experimented with many black oxide finishes but none has proven as successful, safe, and inexpensive as DU-LITEour tools have better sales appeal—our volume has been on the increase ever since we started using this modern, progressive oxide finish."

Depend on Du-Lite, the metal-finishing specialists, for the most efficient and economical cleaners, black oxide finishes and phosphate coatings. Write for full details on

Du-Lite Black Oxide for Steel,

3-0 Black Oxide for stainless steel and malleable iron.

SD Compound for removing occluded salts. Phosteel and Phospray for phosphatizing steel, iron or zinc.

Du-Lite Non-Acid Black Oxide for copper and copper alloys.

Dynakleen for bright cleaning all metals, Kwikseal and Proctoil water displacing oils.

Or send us samples of parts and we will process them for your approval.

Send information Have your repr			
Name			
Company			
Address			
City	Zone	State	
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METAL PROGRESS: PAGE 153

You can cut Cleaning and Peening costs

66%
Park
Cut Wire Shot

Shatter-proof Park Cut Wire Shot is made of hardened clipped carbon steel wire. It will outperform and outlast breakable cast shot. That is why you can save up to 66% in cleaning and peening costs.

- 7. Durability
 Tests prove Park shot lasts from 8 to 10 times longer.
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 One bag of Park shot does the work of 8 bags of cast iron shot.
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 Definite savings on steel costs
 when peening with Park shot.



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MANHATTAN

Abrasive Wheels — Cut-off Wheels Finishing Wheels—Diamond Wheels

Custom-made for your specific material removal problems

Foundry Snagging—Billet Surfacing—Centerless Grinding Cutting and Surfacing concrete, granite, and marble

"Moldiscs" for rotary sanders
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stainless steel welds
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Cutting-off—Wet or Dry Bars, Tubing, Structurals, etc. Foundry Cutting —standard and reinforced wheels

Grinding Carbide Tipped Tools

Write to Abrasive Wheel Department

Raybestos-Manhattan, Inc.
MANHATTAN RUBBER DIVISION
92 TOWNSEND ST. - PASSAIG N. J.

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- Economica
 - No Change in Dimension
 - · Corrosion Resistant
 - Perfect Uniformity
 - Non-Technical

The Black Oxide Finish That Penetrates Iron & Steel Surfaces

PURITAN MANUFACTURING CO. WATERBURY, CONN.

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HERE'S HELP

for your engineerrecruitment problem

Engineers' Joint Council and The Advertising Council offer free, expert help to advertisers promoting engineering as a career.

A booklet has been prepared by The Advertising Council in cooperation with the Engineers' Joint Council to help you in recruiting engineers for the future.

- It tells you what the problem is and the important part you can play in solving it.
- It outlines the advantages of an engineering career to help your company develop advertising appeals.
- It informs you as to the current activities of industry in the education and recruitment of engineers.
- It offers specific suggestions as to what you can do (from present manpower).
- It provides material that you can use in your own local and national programs.

Many companies are using this booklet today. They say that it helps in orienting their engineer-recruitment advertising to industry-wide recruitment programs. Send for the booklet now. Address: The Advertising Council, Inc., 25 West 45th St., New York 36, N.Y.

This space contributed by American Society for Metals



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To Your Specifications or Ardcor Design—for all makes of machines.

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ARDCOR ROLLER DIES . ROLL FORMING MACHINERY . CUT-OFF MACHINES

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Wickliffe, Ohio

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ERICO PRODUCTS, INC.

Complete Arc Welding Accessories 2070 E. 61st Place, Cleveland 3, Ohio

Write for Caddy Catalog

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RESIDUAL STRESS MEASUREMENTS

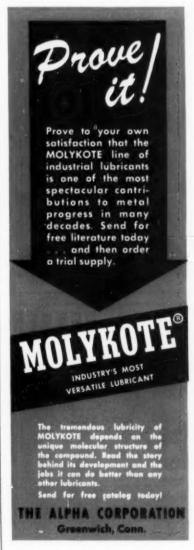
This volume, written by four outstanding authorities, devotes 204 pages to the important problem of the nature and extent of residual or "internal" stresses in metals and metal parts prior to actual structural or operati. g use.

How to measure residual stresses... The state of stresses produced in metals by various processes... Relief and redistribution of residual stresses in metals... How residual stresses originate, their nature and their effect on metals.

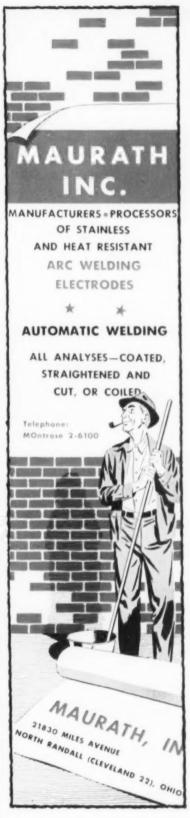
204 pages \$4.50

AMERICAN SOCIETY for METALS

7301 Euclid Ave. Cleveland 3



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LIST NO. 72 ON INFO COUPON PAGE 158

STEELWELD PIVOTED SHEARS

Radically Different

Steelweld metal-cutting shears are entirely new with advantages never before possible. Revolutionary pivoted-blade travels in circular path and overcomes handicaps of ordinary guillotine-type shears. No slides or guides to wear and cause inaccuracies. Many other important features. Complete line machines for shearing metal up to 20 feet long or in thicknesses to 1-1/4 inch.



Straight Accurate Cuts

Not only are these machines easier to operate but their design assures smooth straight cuts to hair-line accuracy for years of operation. Their construction is extra heavy, and all modern features are incorporated to provide for ease of operation, minimum maintenance and long life.

WRITE FOR CATALOG No. 2011.

THE CLEVELAND CRANE & ENGINEERING CO.

939 East 282nd Street . Wickliffe, Ohio

FEATURES GALORE

- 1. All-welded solid one-piece frame.
- 2. Electric foot control.
- 3. Fast Micro-Set Knife Adjustment.
- 4. Deep throat for wide slitting.
- 5. Lift-up Back Gauge.

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Reduce your assembly problems and costs. Our shapes continuously formed, with high degree of accuracy, from ferrous or nonferrous metals. Write for Catalog No. 1053.

ROLL FORMED PRODUCTS CO.

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RUST-LICK IN AQUEOUS SYSTEMS For HYDROSTATIC TESTING Eliminates Rust Fire Hazards Toxicity Dermatitis Washing WISTIT FOR TAXIF & BROCHURE PRODUCTION SPECIALTIES, INC. 755 BOYLSTON STREET BOSTON 16, MASS.

FREE Cutting Oil Chart

Use this free cutting oil chart as a handy guide to production costs and to more effi-

cient machining operations.
Steel and nonferrous metals are charted with the proper cutting oil for many applications. Shows you

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3401 W. 140th St., Cleveland 11, Ohio

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Multifor



Illustrated above are a few of the many forms that can be produced efficiently on the Multiform Bender, using the standard tooling.

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J. A. RICHARDS CO. .

BENDERS-CUTTERS MODELS



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These are claims of users of HANGSTERFER'S LUBRICANTS who are Drawing, Drilling, Reaming or Tapping stainless steel or other hard metals.

HANGSTERFER'S LUBRICANTS are doing the job for major metal working plants here in the United States and in Europe

HANGSTERFER'S LABORATORIES

WOODBURY, NEW JERSEY

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WHITELIGHT

your comprehensive independent source of magnesium alloy Tubes • Rods • Shapes • Bars Mollow Extrusions • Plate • Sheet
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WHITE METAL ROLLING & STAMPING CORP.

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Sales Office 376 Lalayette St., New York 3, N. Y. LIST NO. AT ON INFO COUPON PAGE ISS. **Use Atlantic Fluxes**

For degasifying and purifying aluminum alloys. Assures uni-formly sound, dense grained castings. Used in reverberatory and crucible-type furnaces.

ALUCO 'S' . . .

Specially compounded for die casting aluminum-base metal and permanent mold castings.

MAGNESAL . . .

Used for removing magnesium from aluminum alloys.

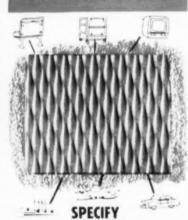
ALUCO 'GR' & 'DG' ...

For grain refining and degast-fying aluminum and its alloys.

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RIGID-tex METALS

Take that new product of yours, make it dent-scuff-scratch-resistant, give it plenty of rugged impact resistance, reduce its weight and double its reduce its weight and double its strength, and finish it up by packing it full of buying-eye appeal. You can do all this when you specify Rigid-Tex Metals right into your product designs! Find out for yourself.

Write on your company letterhead.



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The new miracle-multi-nurnose molybdenum disulfide lubricant.

Anti-Seize is a stable non-melting lubricant having a phenominal capacity to prevent seizing and galling at bearing pressures well over 100,000 pounds per square inch. Anti-Seize will lubricate at temperatures below sub-zero and up to 750 degrees F.

> Write today DEPT MP for new literature and get the complete story

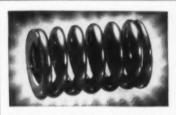


MANUFACTURERS OF THE MOST COMPLETE LINE OF MOLTROCINUM DISCUSSOR LUBBICANTS

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METAL STAMPINGS AND WIRE FORMS

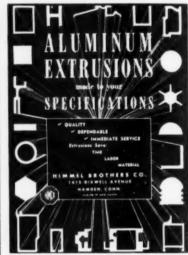
JOHN EVANS' SONS, Inc. PHILADELPHIA 24 PENNA

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GET A BID FROM

SPECIALISTS IN THE FIELD OF

Die Castings

Aluminum and Zinc



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USE OUR

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BRONZES . ALUMINUM COPPERWELD . SILVER PLATED WIRES OTHER NON-FERROUS

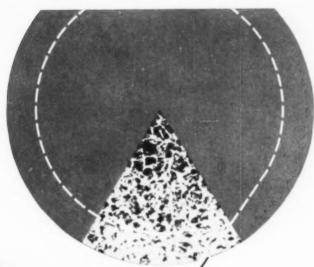
WIRE FLAT ROUND

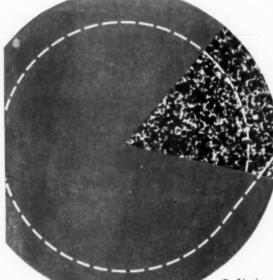
for

- * SPRINGS
- * FORMS
- ELECTRONICS
- SPECIAL PURPOSES

189 Caldwell Ave. . Paterson 1, N. J.

The "decarb" (lightcolored) area in the ordinary heat-treated bar at right must usually be removed before parts can be made from the stock.





Republic Carbon-Corrected Alloy Steel Bars help you make a profit

 Notice, above at the right, the "decarb" area in the outer edge of the cross-section of a cold drawn alloy steel bar as ordinarily heat treated. Then compare it with the cross-section below at the left. Notice how the carbon has been restored by carbon correction even to the extreme outer circumference.

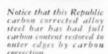
Here, in the outer rim of Republic Carbon-Corrected Alloy Steel Bars, is the profit-area for your machine tools . . . the part of the bar you don't have to machine away into chips and shavings.

Let our Republic 3-Dimension Metallurgical Service work with your metallurgists and production men to adapt Republic Carbon-Corrected Cold Drawn Alloy Steel Bars to your products. Your Republic Steel salesman can arrange for the Republic Field Metallurgist to call at your convenience.

REPUBLIC STEEL CORPORATION

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GENERAL OFFICES • CLEVELAND 1, OHIO
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3-DIMENSION
Metallurgical Service

... combines the extensive experience and coordinated abilities of Republic's Field, Mill and Laboratory Metallorgists with the knowledge and skills of your own enganeers. It has helped guide users of Alloy Steels in countless industries to the correct steel and its most efficient usage, IT CAN DO THE SAME FOR YOU.



INDUCTION HARDENING TEXTILE-MACHINE PARTS AT WHITIN MACHINE CO.

Hardening Output Increased Ten Times With G-E Induction Heaters

"Since changing to General Electric induction heaters for hardening twister rolls we've increased our hardening output ten times and improved product quality!" reports Arno Wagner, heating engineer, Whitin Machine Co., Whitinville, Mass,

When using evanide furnaces for hardening, it took Whitin 312 hours to harden only 11 rolls. Now, by applying selective G-E induction heat, Whitin hardens over 35 rolls per hour! Because parts require no expensive preparation for heating-necessary with furnace hardening Whitin has reduced costs significantly. Hardness tests show induction-hardened rolls to be stronger and of more uniform

Improved working conditions are another benefit now enjoyed by Whitin, because compact G-E heaters eliminate the discomfort of radiant heat and provide cleaner, more comfortable working conditions.

Included in Whitin's heating operation are one 50-kw and three 20-kw G-E heaters. Used primarily for hardening over 500 parts for textile machines, these versatile heaters are also applied for annealing, soft soldering, and silver soldering. In each case, substantial savings in time and money have resulted.

This high-quality selective heating at lower cost is available to you. To learn how you can profitably apply G-E induction heat to your operations, contact your G-E Apparatus Sales representative. And write now for bulletins on G-E induction heaters to General Electric Co., Section 720-118, Schenectady 5, N. Y.



PROGRESSIVE HARDENING twister roll in this G-E fixture is done automatically at the rate of two inches per second.



SURFACE HARDENING machine part is a fast process, Only 20 seconds are required to harden, quench, and remove part.

You can put your confidence in_

GENERAL 🔀 ELECTRIC



READ how you can benefit by JESSOP'S great product variety

Hopes for the future notwithstanding, Jessop lays no claim to being the largest specialty steel maker in America, but careful check shows it to be the most diversified. We produce the greatest variety of special steel products, shapes and sizes available anywhere. There's a profit story in this for Jessop and for you, too. We profit by spreading ourselves across a greater segment of industry. Like a modern investment trust we avoid the ups and downs of vertical markets. Our current sales success proves the point. You can profit if you come to Jessop for more of your requirements and obtain the service and delivery advantages that single-source provestics off or Whet's ground to the service and the service of the Whet's ground to the service of the Whet's ground to the service of the Whet's ground to the service and the service of the Whet's ground to the service of the Whet's ground to the service of the whote's ground to the service of the true to the service of the true to the service of the service of the true to the service of the true to the service of the true to the service of the true true to the service of the service of the true true true to the service of the se

purchasing affords. What's more, you'll enjoy doing business with the Jessop team . . . aggressive men eager to earn their salt by helping you in your business. Check the list on this page and pick more products to buy from Jessop. You'll be glad you did.

Products

STANDLESS STEELS MIGH SPEED STEELS

NON-MAGNETIC STEELS

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MEAT RESISTING STEELS

STAMLESS-CLAD PLATES

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TEMPERED AND GROUND STRIP

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COMPOSITE MIGH SPEED STEELS STAINLESS AND MEAT RESISTING

COMPOSITE DIE STEEL SECTIONS

PRECISION GROUND FLAT STOCK

DIE STEELS-BOT AND COLD WORK

133313

STEEL COMPANY . WASHINGTON, PENNSYLVANIA

Customer Reports:

"We Switched to Continuous-Cast Bronzes... Rejects Now Negligible...No Field Failures"

JACUZZI BROS., INC., Richmond, Calif., had heavy losses due to rejects of pump bearings made from sand-cast bronze.

"Since switching to Asarco Continuous-Cast Bronzes (75% Cu, 5% Sn, 20% Pb, and 83% Cu, 7% Sn, 7% Pb, 3% Zn), REJECTS ARE NEGLIGIBLE, and there have been no field failures," says Mr. R. Delahay, Jacuzzi production engineer.

Here's why Asarco Continuous-Cast Bronzes cut rejects:
porosity, dirt. hard and soft spots are non-existent; alloy constituents
are uniformly distributed. Also, dimensions are held to
close tolerances: +0.004" to -0.006" on O.D., and tube concentricities
to within 1.5% of wall thickness. Fatigue and impact
characteristics are up to 100% better than those of sand-cast or
permanent mold stock; tensile and yield strengths are
appreciably higher. All stock for machining is Medart-straightened.

Asarco Continuous-Cast Bronzes are available in rods, tubes and shapes . . . in many alloys, made to your specific requirements if necessary. Lengths are cut to the exact size you want up to 12' (standard) or 20' by special arrangement.



West Coast Sales Agent:
KINGWELL BROS, LTD, 457 Minna Street, San Francisco, Calif

American Smelting and Refining Company

OFFICES: Perth Amboy Plant, Barber, New Jersey Whiting, Indiana

METAL PROGRESS: PAGE 160-B

By HOWARD VANDERPOOL Consultant Metallizing Engineering Co. Long Island City, N. Y.

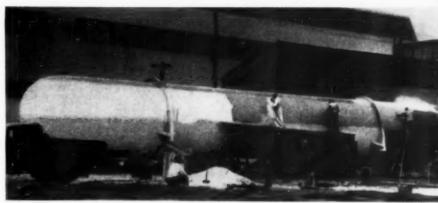


Fig. 1—High-Pressure Gas Tanks Metallized With 0.003 In. Zinc in 1932 Were in Excellent Condition in 1950. Only maintenance given was in 1941 when a few thin spots were touched up. Tanks are in a sea-coast atmosphere containing acid fumes from nearby refinery

Prevention of Corrosion by Metallizing the Surface

 $\mathbf{I}^{ ext{N}}$ SPITE OF THE FACT that metallizing first saw the light of day back in 1908, very little is yet known about it by those not actively engaged in its use. Major American industrial organizations have taken advantage of the fact that molten metals can be sprayed onto dry surfaces and will stay there through stress and strain, vet many engineers are still under the impression that this process is new and unproven. The electrical manufacturing industries, the automobile makers, even the Army and the Navy, have been utilizing coatings applied by metallizing guns. Some have special departments headed by senior engineers. Many such organizations have conducted extensive studies to develop new uses, not only in maintenance, but in the design of major products.

Metallizing applications are roughly divided into two groups. First is the building up of relatively heavy coatings on machine elements, generally followed by machining, grinding or polishing. Whether a turbine shaft is to be sprayed with 0.25% carbon steel to restore the journal diameter, or a packing gland section is to be built up with stainless steel, the general

technique involved is the same. The former is for a dimensional adjustment whereas the latter is to provide a corrosion-free surface.

The second class of work done is in the corrosion field. This generally refers to coatings of zinc or aluminum on iron or steel. This is the area of application that will be discussed.

THEORY OF CORROSION

In any discussion of corrosion and its mitigation, the theory of corrosion must first be agreed upon. Primarily as a result of work done by the National Association of Corrosion Engineers and by the Electrochemical Society, it is generally accepted that corrosion is electrolytic in action. This means that there must be present (in one form or another) an anode, a cathode, an electrical conductor between the two, and some sort of an electrolyte. High school physics has taught us that when dissimilar metals are immersed in an electrolyte and a galvanometer is inserted between them, a current will be indicated; one metal suffers degradation, while the other remains essentially

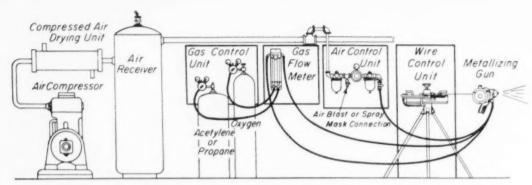


Fig. 2-Typical Metallizing Installation. Compressed air is supplied at 40 cu.ft. per min. and 40 to 60 psi. pressure to spray the melted metal

intact. The anode is the unfortunate partner; the cathode or the more "noble" metal is protected. Therefore, in the design of equipment subjected to corrosion, bimetallic arrangements should be avoided. Steel water tanks are certainly not bimetallic in construction; vet corrosion can and does cause millions of dollars worth of damage to them each year in the United States. The reason for this is simply that no steel or iron can be made without incidental inclusions of impurities. Once pitting corrosion has begun at such an impurity, the corrosion products themselves produce what is, in effect, an electrolytic couple. Mill scale on hot rolled steel is a notable example of a cathodic material electrically attached to the base material. A break in a continuous mill scale coating, exposing the bare metal underneath, can cause serious pitting in very short order. Even grain boundaries or residual stresses, as well as concentration differentials in

the electrolyte, can set up a relative difference in potential.

The normal corrosion rate of steel or iron is not too dangerous. Pitting and localized attack are the culprits that produce leaks and weaken the structures.

There are essentially four methods of combatting corrosion. Number one is a barrier—an inert film—to isolate the electrolyte from the base metal. New plastic materials such as vinyls, rubbers and phenolics have done much to impede the advances of corrosion. These materials are highly resistant to moisture absorption and transmission, as well as being inert to many chemical reagents.

Second is substitution. The use of corrosion resistant metals or alloys as replacements for iron and steel is quite common. Stainless steel, nickel and Monel are representative. Here an attempt is made to produce a base metal which is capable of remaining intact although it is in

4 in. Minimum 10 in Maximum Characteristic Luminous White Cone of Balanced Oxy-Acetylene Flame Sprayed Metal Melting Wire Compressed Air. Oxy-Acetylene or Oxy-Propane Gas ---Wire-Wire and Gas. Nozzle Air Cap Burning Gases Atomized Spray Air Envelope Prepared Base Material

Fig. 3-Cross Section of "Metco" Hand-Operated Metallizing Gun

METAL PROGRESS; PAGE 162

intimate contact with the electrolyte. Use of such materials requires that careful consideration be given to the corrosion-producing electrolyte. For instance, all stainless steels are not resistant to all reagents. There is no "master" alloy. In general, their ability to resist corrosion stems from the film-forming ability of these metals. The theory of this mechanism is rather involved and it will serve no purpose to discuss it here.

The third means of corrosion protection is water treatment, or special treatment of the solutions causing the attack. Water treatment in boiler work is fairly well known in industry. Naturally, there is a limitation to the additives that can be used in most attacking liquids.

The fourth and perhaps newest means of corrosion prevention is cathodic protection. Cathodic protection means that the attacked metals. which are normally anodic, are artificially made cathodic by connecting an anode to the base metal, or by impressing a proper direct-current potential to the corroding material. In other words, the latter type of corrosion protection is a "reverse plating operation". Careful engineering and maintenance of a cathodic protective system can completely stop corrosion, provided only that the scheme can be made effective.

It is almost a trite saving in corro-

corrosion mitigation can provide all of the answers. Many times, combinations of systems will approach complete immunity. For instance, in the protection of exterior underground pipe lines, cathodic protection would require rather high current densities (or potentials); however, when such pipe lines are painted, it is necessary to provide a minimum of power to protect the pipe at the breaks or voids of the paint film.

sion circles that no one method of

METALLIZING

Metallizing systems, as they apply to the prevention of corrosion of iron and steel, are unique in that they can provide in one treatment three of the four means of corrosion prevention-barrier, substitution, and cathodic, as will be explained later. In addition, because metallizing actually provides a film of metal, a harder surface is produced than with organics. This discourages abrasion which is often the initial cause of the breakdown of protective films.

Normal corrosion resistant surfaces are usually zinc or aluminum on iron or steel. The reason for this is that these two metals are effectively cathodic to ferrous metals. This accounts for the cathodic protection afforded by such coatings. Fairly

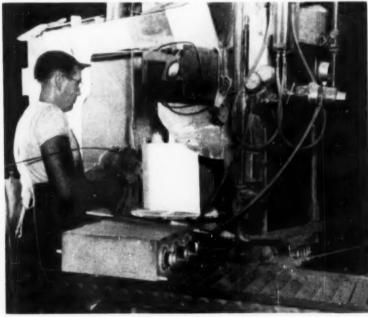


Fig. 4-Westinghouse Capacitors for Outdoor Installation Being Coated by Metallizing With 0.010 In. Zinc



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Prevention of Corrosion by Metallizing

(Starts on p. 161)

thick layers are also easily laid down, whereas a coating of metallized stainless steel, nickel or Monel can only be applied on a water tank to a thickness of about 0.010 to 0.015 in. Heavier coatings require more elaborate preparations, pushing costs above a practical point, and if such a coating is perforated by mechanical abuse, a potential is set up between the base and the coating which will actually accelerate corrosion of the main body of the vessel. In other words, the corrosion resistant nickel-chromium alloys are anodic to plain

irons and steels. Cathodic coatings should be avoided where only relatively thin films are obtainable.

Metallizing costs are initially higher than painting costs, so the layer must last longer and give a higher degree of protection. The following instances will indicate the high rating of metallization on both counts.

Perhaps the first known application of sprayed zinc still providing complete protection is on a lock gate in the St. Denis Canal in Paris, France. The most recent report from the Societe Nonvelle de Metallisa-

(Continued on p. 166)

Typical Coatings for Various Exposures*

General Considerations

Each specific application must be evaluated on the basis of the actual conditions to be encountered; therefore, the recommendations given herein are intended only as a guide in arriving at the final coating for a given job.

Atmospheric Exposure

Where galvanizing or similar methods are satisfactory, sprayed zinc 0.003 in, thick followed by one or two coats of chlorinated rubber or aluminum vinyl could be used.

Salt Atmospheres

For average salt atmospheres without salt spray present, zinc or aluminum 0.005 in, thick plus two coats of aluminum vinyl may be used.

For salt atmospheres where salt spray will be present, zinc or aluminum 0.008 in, thick plus one coat of proper primer and two coats of aluminum vinyl may be used.

Industrial Atmospheres

For industrial atmospheres, the use of aluminum is recommended exclusively since it provides much better protection against sulphurous gases (sulphur dioxide, hydrogen sulphide, etc.) and other gases encountered. For average industrial atmospheres, a coating of aluminum 0.005 in, thick plus two coats of aluminum vinyl may be used. For heavier industrial atmospheres, a coating thickness of 0.008 in, plus two coats of aluminum vinyl should be used.

Fresh and Salt Water Exposure

For exposure to fresh water having a pH value of over 6.5 and to salt water, only zinc is used, the coating thickness being 0.010 to 0.015 in. This is satisfactory only when the water temperature does not exceed 120° F. Zinc coatings also have some antifouling properties. In salt or brackish waters, one or two sealing coats of chlorinated rubber may be used.

For fresh water, where the temperature is not over 120° F. and where the pH is 4.5 to 6.5, 0.012-in, thick aluminum is used without sealing coats. For this application 99% aluminum should be used.

^{*}From "Recommended Practices for Metallizing: Part IB—Application of Aluminum and Zinc for Protection of Iron and Steel", American Welding Society, 1952.

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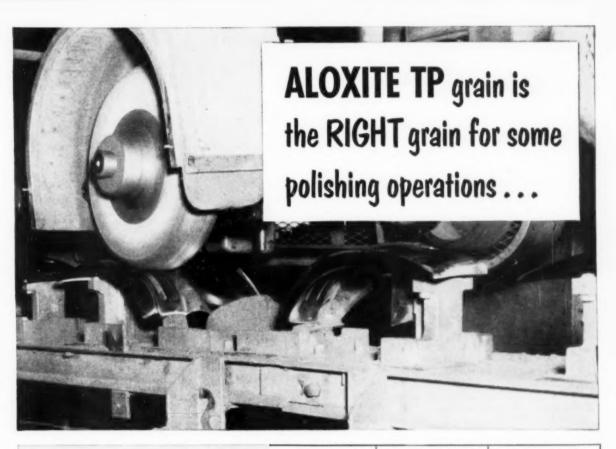
Corrosion Prevention by Metallizing

(Starts on p. 161) tion indicates that, though never painted, there is no rust.

Twenty years ago, one of 14 coal barges operating in the Delaware River at Philadelphia was treated with a metallized coating of pure zine on the hull as well as the interior of the eargo holds. This barge is still operating with practically no maintenance required by corrosion, although it was not a new vessel when first treated. Subsequently, 14 other vessels were similarly metallized. The ice and trash conditions on the Delaware River have actually worn off the zinc in areas at the waterline and under the bows of some of these barges. At these points, additional zinc has been applied. The work has been successful to the point that the owners consider it essential to the economical operation of their equipment. Perhaps if the modern practice of applying heavier coatings. of sprayed metals at the area subjected to heavier abrasion had been followed, no additional maintenance would have been necessary in this 20-year period,

The Riverhead Water District in New York provides another bit of evidence which is similar to an example of metallizing in Pennsylvania. The interior of the Riverhead elevated water storage tank and the hull of a tugboat were both metallized some 18 to 20 years ago. Rather thin coatings of zinc were applied, since the guns sprayed slowly in those days. After 15 years, both the tug hull and the water tank were completely protected from corrosion, yet inspection two years later indicated that no zinc remained!

This termination of protective life is explained as follows: The life of protection afforded by any anodic metallic coating is a function of its thickness or weight. In both the tank and tug, steel eventually was exposed at the thinner areas. Each additional square foot of newly exposed steel threw a greater load on the remaining zinc anode. Because this bare steel was being protected by the sacrificial action of the zinc, the rate of dissipation of the zinc increased with the increased area of cathodic steel. (Cont. on p. 168)



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Corrosion Prevention by Metallizing

(Starts on p. 161)

The foregoing hypothesis is substantiated by tests that were made by two major shipyards some 15 years ago. Simultaneously two yards tried zinc metallizing on test panels on the bottoms of rather large ships. These areas, though large, were small compared to the uncoated surface. After a relatively short time, the vessels were drydocked and it was noticed with some disappointment that all of the zinc had disappeared. What was not realized at the time was that during the period that the zinc was still active, it was providing cathodic protection to the surrounding steel. Undoubtedly these same ships carried zinc plates under the sterns and probably these were replaced during the drydocking period. Evidently no concern was felt over the loss of zinc plates although the loss of zinc metallizing was viewed with some raised evebrows. To effectively prevent corrosion below waterline it is necessary to treat the entire area. Small breaks in the film, which expose very small areas of steel cathode, are not damaging, for these small areas are very effectively protected by the overwhelmingly large area of anodic zinc.

It is estimated that in the United States alone some 300 ships have been treated with metallizing systems. Abrasion of hulls by docking or by flotsam is paralleled in other industries. Elevated water storage tanks in the northern states will freeze over in the wintertime and as the water level rises and falls, an ice "plug" scrapes against any protective film. Even if this does remove some zinc, the remaining coating cathodically prevents corrosion of the exposed steel. The Erie Water District in Northern Pennsylvania has had some interesting experiences with metallizing going back 20 years. One involved leaky filter troughs. It was decided to try zinc metallizing to stop the leakage and to maintain the troughs until new ones could be installed. Today, over 18 years later. those same troughs are in use.

The Panama Canal Zone Authority has studied protective systems to be used on lock gates in tropical en-(Continued on p. 170) PANGBORN SPEEDS UP PRODUCTION, LOWERS COST

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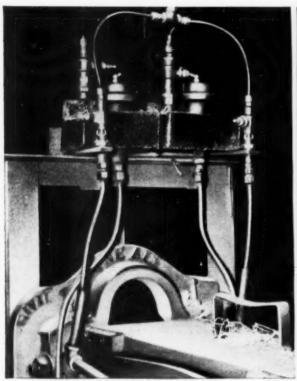
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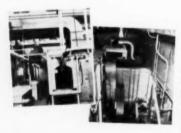
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Corrosion Prevention by Metallizing

(Starts on p. 161) vironment. After laboratory exploration, several promising coatings were applied. Ten years later a report in Corrosion concluded:

1. The systems which show outstanding performance are those metallized with zinc.

Zinc metallizing provides a sacrificial prime coat which acts as secondary protection if and when the organic top-coats have deteriorated or become damaged.

3. Zinc metallizing is not considered justifiable if the length of the service period is relatively short—for example, four or five years—and regular maintenance repairing or repainting is the rule at the end of such relatively short periods.

SPRAYED ALUMINUM

Severe corrosion problems exist in the maintenance of contact sulphuric acid plants. Monsanto Chemical Co, and Leonard Construction Co, have jointly developed a specification that has become standard procedure in the manufacture of equipment for these conditions.

In the converter, the hot heat exchanger, and piping connecting these units, the steel is exposed to temperatures ranging from around 850 to as high as 1150° F. The equipment contains a gas composed of up to 10% or more SO₂ which, enroute, is converted into a mixture of SO₂ and SO₃ at the high temperature. Bare steel tends to "scale", and while this is not at all serious from the point of view of converter life, some scale drops off into the catalyst pellets and increases resistance to proper flow of the gas.

Metallizing with approximately 0.010 in. of aluminum very materially stops this scaling. How long the job will last is not known, but it is well worth it if metallizing needs to be done even as often as six-year intervals.

Organic paints do not hold up under high temperature on such equipment as exhaust manifolds, mufflers, and smoke stacks—even in more conventional industries. It is standard procedure at Bethlehem Steel Co., for example, to metallize

(Continued on p. 172)



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Corrosion Prevention by Metallizing

(Starts on p. 161)

the exteriors of smoke stacks and waste heat exhausters with aluminum. Mufflers on Cooper-Bessemer gas engines are similarly treated. Some of this work has been done for over 20 years.

Recent investigations into the use of silicone-aluminum paints have discovered that thinner layers of sprayed aluminum will serve as undercoats if these organic materials are painted or brushed over the sprayed metal. It is a question as to whether these paints remain stable at elevated temperatures; however, it is conceded that even though the vehicle may burn out, the heavy pigmentation remains in the pores and irregularities of the sprayed coating, thus extending its total life.

COMPLEX COATINGS

It should be mentioned here that there are two patented processes. known as "Metcolized" * coatings, which use nickel-chromium sprayed metal with or without a subsequent coating of sprayed aluminum. In environments where these systems are used, the initial heat will fuse the sprayed coatings to the ferrous metals, creating solid intermetallic solutions on the surface. The nickelchromium alloy is applied for temperatures ranging around 1800" F., and the nickel-chromium plus aluminum is for similar environments containing sulphurous compounds.

Bethlehem Steel Co, has set up a department to apply "Metcolizing" to annealing covers used in the heat treatment of strip or wire in the Sparrows Point plant in Maryland. The covers are made of inexpensive mild steel and sprayed on the exterior surface.

The glass-lined tanks widely used in the manufacture of beer, food and chemical products often are damaged through mechanical abuse or accident. When the glass coating is ruptured it is usual procedure to use metallizing guns to spray small quantities of tin or other corrosion resistant metals—sometimes even gold, silver, molybdenum or platinum—on the crazed areas.

*Registered, U.S. Patent Office.

The following, because of its importance in the consideration of metallizing, bears repeating. In ordinary corrosion, such as that found in fresh water, polluted water, and salt water, and in rural, industrial and seashore atmospheres, zinc or aluminum is generally covered with organic coatings. Where environments are encountered which would rapidly attack these white metals, stainless steel, nickel, Monel and other metals can be used, but as these are inherently cathodic to steel, special consideration must be given to their application and use,

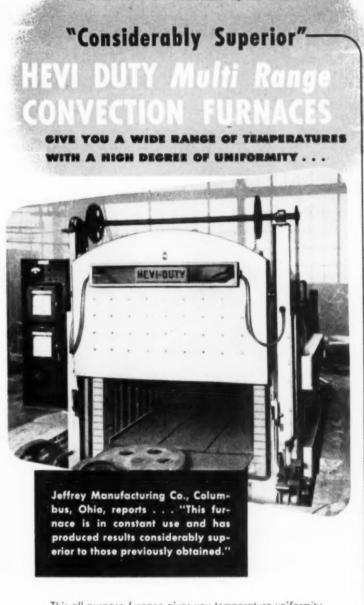
Although metallizing was first used more than 40 years ago, it has only recently gained general acceptance. This is primarily due to the development of faster and more efficient metallizing equipment. Faster metallizing means more economical metallizing. This, coupled with the increased labor rates for union painters, has brought metallizing to a position where it is frequently more economical to metallize than to paint, the only qualification being that long-life protection is desired.

High-Temperature Fatigue*

In the operation of gas turbines at high temperature, the stress conditions may be such that both fatigue and creep of some of the components occur. This is especially true for the rotating turbine blades. These two properties should be considered together for a proper appreciation of the reaction of metals to the stresses that are likely to arise in gas turbine operation.

At room temperature, steels and some other metals possess definite latigue limits which are independent of the number of stress cycles and are little affected by the speed of cyclic change of stress; no such definite limits are found at high temperatures—that is, the curves don't usually have a "knee". Alternating fatigue stresses at high temperature are therefore normally recorded as the stresses producing failure in a particular time, or at a specified number of stress (Continued on p. 174)

★Digest of "Fatigue at High Temperatures", by H. J. Tapsell, Symposium on High-Temperature Steels and Alloys for Gas Turbines, British Iron and Steel Institute, February 1951, p. 169-174.



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High-Temperature Fatique

(Continued from p. 173) cycles, such as stress for failure in 10° eveles.

In practice, the cyclic stresses are usually superimposed on a static stress, and creep may accompany fatigue. If the stress is small in relation to the cyclic stress, creep will be small or negligible and failure will be by fatigue, but with high static stress, creep is the predominant factor leading to failure in a time mainly determined by creep properties. At high temperatures under vibratory stress the number of cycles to fracture is a function of the cyclic speed; the time factor, therefore, arises in an additional form. The magnitude of the effect of cyclic speed has not been studied by the author for increasing values up to the resonant vibration speeds of turbine blades, but the evidence so far obtained at lower speeds suggests that the fatigue strength for a fixed number of cycles at resonance speeds is somewhat higher than at the normal (slower) laboratory testing speeds of about 2000 to 10,000 cycles per minute.

When a component is subjected to alternating bending stresses, their magnitude may be sufficient to produce plastic strain in the most highly stressed fibers, causing stress redistri-

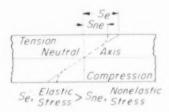


Fig. 1-Stress Redistribution in a Component Subjected to Alternating Stress. Solid line represents linear elastic distribution; dashed line represents when plastic flow occurs

bution across the section. A typical stress redistribution might be as shown in Fig. 1, wherein the solid line indicates linear elastic distribution and the dashed line the distribution if plastic flow occurs. The nature and extent of the redistribution will depend on the form of the stressstrain relation determined at the same loading speed as the alternating (Continued on p. 176)

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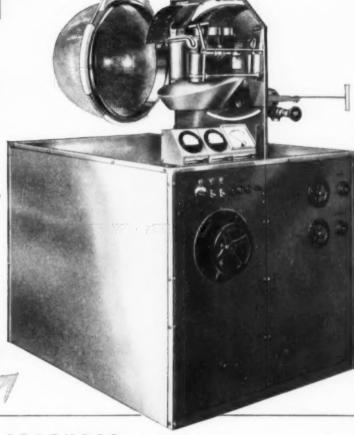
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High-Temperature Fatique

(Continued from p. 174)

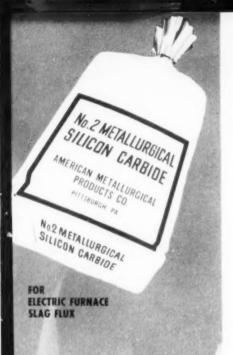
Under alternating direct stress, when the maximum stress of the cycle exceeds the elastic limit, a hysteresis stress-strain loop is developed representing work done. With a rectangular beam of material under alternating plane bending at constant maximum strain, each fiber strained beyond the elastic limit develops a lower stress than the nominal value, Sno < So. When the cyclic frequency is increased, plastic strain has less time to develop and the stress in the outer fibers strained beyond the elastic limit, Sne, more nearly approaches the nominal value, S,; that is, the actual stress is higher. The hysteresis loop correspondingly decreases in width as the evclic speed increases, and there is less work done on the material per cycle. The relationship between the work done per cycle and the number of cycles to fracture is unknown. It may be assumed, however, that under alternating stress cycles, the number of cycles to fracture will depend on the cyclic speed but is unlikely to be a direct function of the speed. The relationship is probably approximately logarithmic, as has been found for mild steel at 400° C. (750° F.).

At very high cyclic speeds there is little time for plastic yielding at the maximum stress of the cycle; therefore, the actual stress for a given deflection or bending moment is probably very close to the stress computed from an elastic formula.

Since the maximum fiber stress in bending may be distinctly less than that based on an elastic state of distribution, a material undergoing alternating bending may appear to withstand a higher (nominal) stress for a given endurance than when subjected to alternating direct stress. In gas turbine blades, however, the speed of alternating bending is so high (60,000 cycles per min.) that the bending stress may be very close to the computed elastic stress.

Data are presented for the fatigue and creep properties of five alloys, R.ex 78, Nimonic 80, G18B, G32, R.ex 337 A, at temperatures from 600 to 800° C. (1110 to 1470° F.) for times from 10 hr. to, in some instances, in excess of 1000 hr.

(Continued on p. 178)



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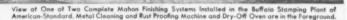
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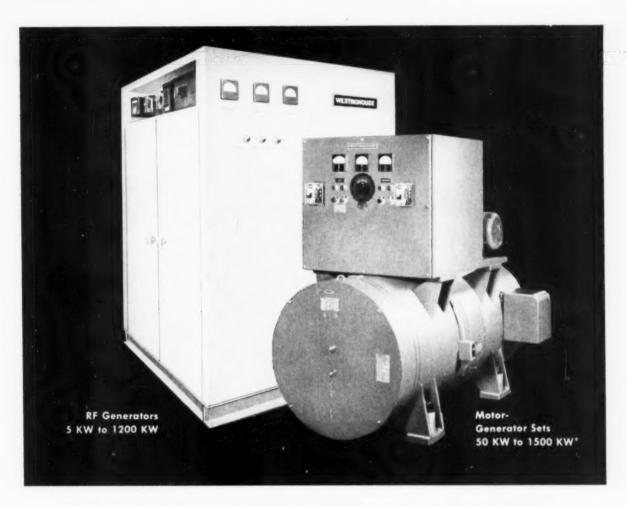
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High-Temperature Fatigue

(Continued from p. 176)

A method is presented to correlate fatigue and creep data into composite diagrams for design use where static and vibratory stresses appear in combination. A typical fatigue-creep diagram, for Nimonic 80 at 700° C. (1290° F.) and a time of 200 hr., is given in Fig. 2. The curve ABCDE shows various stress combinations to give fracture in 200 hr. at 700° C. Point E is pure creep failure, no vibratory load, and point A is pure fatigue failure, no static load. Comfatigue failure, no static load. Comfatigue failure, no static load.

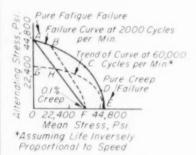


Fig. 2 - Fatigue-Creep Diagram

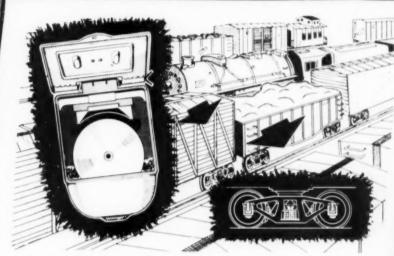
binations of static and vibratory stresses to give fracture time of 200 hr, are on the curve between A and E. The point F represents the tensile stress that, if applied alone, produces a definite amount of creep allowable in the particular design—in this case 0.1% in 200 hr. Theoretically, the limiting curve of 0.1% creep would be the form shown by FB, and this has been approximately confirmed for a mild steel at 400° C. In the absence of experimental information, it is safest to assume that the 0.1% creep line lies along FA.

Although increase in cyclic speed results in a higher stress for a given fatigue endurance, there is evidence that, at a given stress, increase in cyclic speed results in shorter life in terms of time. A safe assumption is that time-to-fracture is reduced in an inverse ratio to the increase in speed. (It is very probable that this ratio is decidedly over-cautious.) Thus, if an increase in speed from the laboratory test speed of 2000 cycles per min, for turbine blades shortens the fatigue life in the inverse ratio,

(Continued on p. 180)



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Performance of railroad journal bearings, under heavy load applications at relatively low speeds, can not be anticipated by the usual physical tests of tensile strength, elongation, etc. Since it is impossible to maintain a perfect oil film between the rotating journal and bearing, the behavior of bearing metals under momentary metal-to-metal contact becomes a major distinguishing characteristic.

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High-Temperature Fatique

(Continued from p. 178) then the stress to give failure in 200 hr. at 60,000 cycles per min. would be the same as that to give failure in 6000 hr. at 2000 cycles per min. Thus, in Fig. 2 a lower curve than ABCDE (2000 cycles per min.) has been shown at GHE representing 60,000 cycles per min.

The area OGHF then approximately represents the limiting stress conditions within which fatigue failure or creep exceeding 0.1% will be avoided. A third dimension or coordinate may be added to make the figure cover a range of times,

In 1942 some additional fatigue tests were made wherein it was shown: (a) That neither R.ex 78 nor Nimonic 80 showed any appreciable loss in strength at 650° C. (1200° F.) when subjected to exhaust gases from a combustion chamber burning kerosene; however, alloys used for blades may suffer reduction in both fatigue and creep strength from ash deposit from the burning of residual oils containing V2O5; (b) specimens of R.ex 78 and Nimonic 80 of rectangular section with small fillet radii of 0.015, 0.025 and 0.040 in. loaded with fluctuating stresses at 650° C. suffered some reduction in endurance; and (c) on the basis of fatigue testing at 650° C., satisfactory welds could be made between Nimonic 80 and Stayblade or Nimonic 75, and between R.ex 78 and Stayblade.

G. M. AULT

Hot Workability of White Cast Iron*

WHITE cast iron, because of the presence of free cementite, is very hard and therefore difficult to machine. For this reason, the direct use of this material is limited to specialty products, such as chill east rolls, rolling stock wheels, and the like. However, since it contains a relatively high percentage of austenite at temperatures above Art. east iron should possess a fair amount of plasticity when hot, and be amenable to forging or pressing. Fur-(Continued on p. 182)

★Digest of "Plastic Forming of White Iron Castings", by G. I. Pogodin-Alexeyev, Vestnik Mashino-stroyenya, Vol. 31, April 1951, p. 57.

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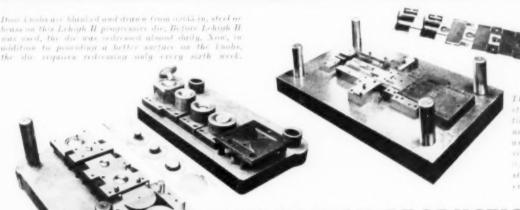
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Tool Steel Topics

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L Severe Service, Lehigh II is a deephardening steel, even in large sections, and has high compressive strength.



When three die rings were needed for high production blanking of covers for large trans for shipping eachide, the mannfas turer specified that each ring be held to close tolerances, and after hardening have a Euclidell-Chardness of \$1 to \$3. The rings a Kierweit narmann is half Each was given a C scale Kockwell test at from prouts, with these condition King 1: 61, 62, 61, 61; King 2: 62, 63, 65, 65, 67, 61, 61.



Peeling Off Ribbons

This chip is curling off the tread of a ing tool, nearly hidden at the left, is made of Bethlehem to High Speed Steel, and is used for both roughing and finishing. On untreated wheels these tools average about 45 wheels before regrinding is necessary; on heat treated wheels, they

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Hot Workability of White Cast Iron

(Continued from p. 180) thermore, plastic deformation may accelerate graphitization, thereby reducing the time required for obtaining malleable iron products.

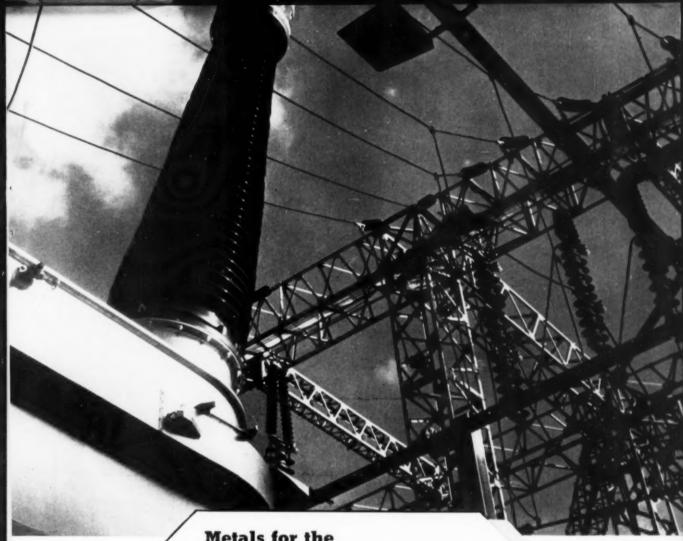
Various experiments were carried out under both laboratory and works conditions to verify these suppositions. The iron used contained 2.23% C. 0.52% Mn, 1.39% S. 0.122% P, and 0.034% S, and had a hardness of 400 Brinell. The strongly dendritic structure consisted of cementite in a pearlite matrix, and there was no indication of free graphite.

A series of preliminary tests was carried out to establish the best heating schedule for subsequent working. For this purpose a number of cylindrical specimens 0.4 in. diameter were heated for 10 to 60 min. at various temperatures between 1290 and 1740° F., and either allowed to cool in air or quenched in water. It was found that heating for only 1 hr. at 1560° F. or 10 min. at 1740° F., caused the formation of isolated graphite globules, and it was concluded that preheating for 10 to 15 min. at 1650 to 1740° F. is most convenient for the purpose. Unless otherwise stated, such treatment was applied throughout the

Upsetting tests were performed on cylinders 1.4 in. diameter and 1.6 in. long in the as-cast condition. These could be reduced without any trouble to 1/3 of the original length by employing light blows of a 500-lb, pneumatic hammer. They also withstood compression of 75% without developing cracks.

Microscopic examination of the upset specimens showed a considerable proportion of graphite, which exceeded many times the minute quantities found after heating to the forging temperature only (without subsequent plastic deformation). Moreover, the amount of graphite in the microstructure increased with increasing plastic strain suffered by the metal. The distribution of the newly formed graphite and its form were not uniform; at the periphery of the forged samples it appeared in the form of small "dots" and fine latelets while in the center as fairly large, irregular areas. Also, the orig-

(Continued on p. 184)





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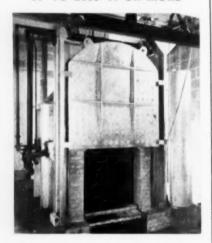
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Hot Workability of White Cast Iron

(Continued from p. 182)

inal dendritic structure became fainter or even vanished entirely in some places. It was found, too, that annealing at 1740° F. produced a malleable iron structure (pearlite plus graphite) in the forged specimens in less than half the time required for the as-cast material.

Attention is called to the fact that the upper margin for the forging temperature is narrow, and that the impact energy of the individual blows of the hammer must be low. When an attempt was made to upset a cylinder with one or two heavy blows, extensive cracking resulted. A similar behavior, in spite of careful hammering, was noted when the cylinder was preheated to 1830° F. Cast bars can be forged down to reduce their cross section if these limitations are kept in mind.

Apart from the experiments described above, various other forming operations were successfully performed. For instance, cast flats of 0.6x0.24-in. section and about 3 in. long could be bent in a vise under 90° or twisted over 360° into a spiral without cracking. But when similar operations were attempted on samples preheated to 1795 to 1830 F., the specimens fractured immediately in a brittle manner without any prior plastic deformation. The author suggests that this behavior may be due to the presence of minute quantities of low melting point eutectics coupled with intensive graphitization during forging at high temperatures.

Finally, flat prismatic specimens from several casts were heated to different temperatures between 1435 and 1650° F. and then quenched into a bath of molten NaNO₃-KNO₃ (435 to 455° F.). After a brief immersion in the isothermal bath, the samples could be bent or twisted in the same manner as the samples receiving treatment at 1650 to 1740° F. The plasticity decreased, of course, as the austenite-to-martensite transformation progressed until the metal became completely brittle.

These results indicate that there may be a possibility of replacing casting by forging or pressing in the manufacture of certain malleable

(Continued on p. 186)

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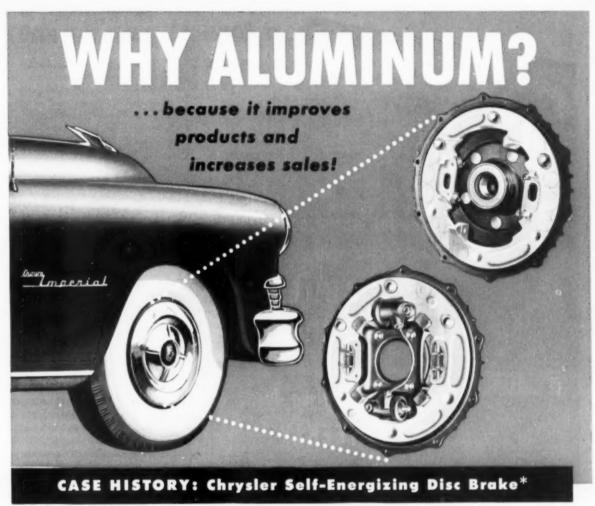
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(Continued from p. 184) iron products. In that way one could produce malleable parts of more difficult forms and to closer dimensional tolerances than easting permits. Also, the annealing period for mechanically worked products would be much shorter than for those cast only.

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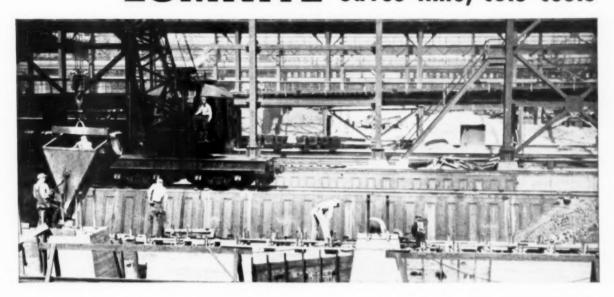
Effects of Alloying on Strain Aging of Rimming Steels*

Tins investigation was undertaken to determine the effect of vanadium or chromium additions on the strain aging of rimming steels. Previous investigators have claimed that the addition of 0.03 to 0.15% vanadium or of 0.30% chromium produces a high resistance to strain aging without affecting the rimming properties of the steel. The experimental procedure consisted of: (a) selecting a suitable test to measure resistance to strain aging; (b) determining the effect of vanadium additions by studying the resistance to strain aging in specimens prepared from laboratory, 10-ton openhearth. and 8-ton bessemer heats of rimming steels in which the vanadium varied from 0 to 0.16%; and (c) determining the effect of chromium by studying the strain aging in specimens prepared from a series of laboratory heats in which the chromium was varied from 0 to 0.44%.

The tensile test was selected to measure resistance of the various steels to strain aging. It was concluded from an analysis of the tensile data obtained from bright annealed sheets of an openhearth and a bessener steel that the rate and extent of strain aging are reflected in data obtained from tensile specimens which have been strained in a tensile machine to 75% clongation, aged at 212. F. for various times up to 24 hr., and loaded in the tensile machined on p. 188)

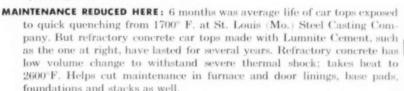
*Digest of "Effects of Vanadium or Chromium on the Strain Aging of Rimming Steels", by W. R. Jones and G. Coombes, Journal of the Iron and Steel Institute, Volume 174, May 1953, p. 9-15.

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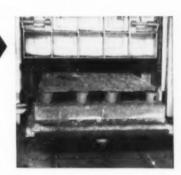
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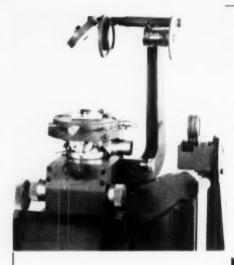
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Effects of Alloying on Strain Aging of Rimming Steels

(Continued from p. 186) chine to failure. It was considered that steels which showed no increase in vield strength after straining and aging in this manner would not strain age at room temperature. In those steels which did strain age. the resistance to aging was measured by plotting the fractional increase in the yield as a function of the log of the aging time at 212° F. The aging time which corresponded to the midpoint in the increase in fractional yield from zero to maximum was used as the index of the steel's resistance to aging.

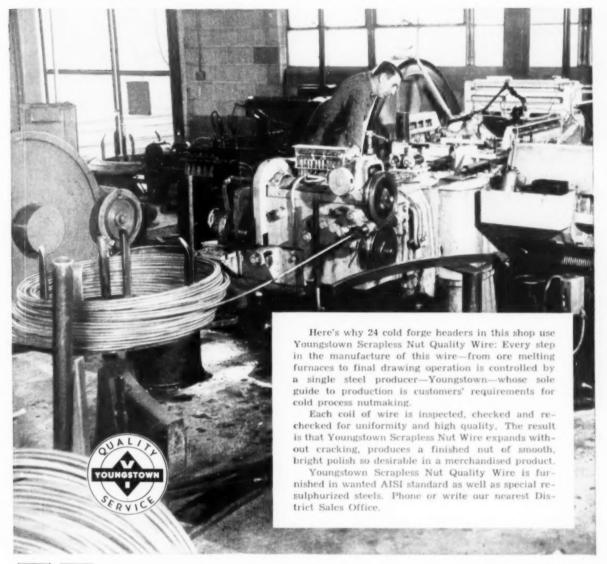
A series of 16-lb, laboratory heats of vanadium-bearing rimming steels was melted in an induction furnace and teemed into cast iron molds for round bars. These heats contained 0.13% C, 0.30% Mn, and 0 to 0.25% V. Vanadium up to 0.10% had no appreciable effect on the rimming action. These bars were forged and rolled into 20-SWG hard strip. After bright annealing at 1256° F. for 20 hr., tensile specimens were cut in the direction of rolling and tested for strain aging. It was found that vanadium additions in quantities greater than 0.027 produced essentially a

nonaging steel.

Following the laboratory experiments, four 10-ton ingots of openhearth and one 8-ton ingot of bessemer vanadium-treated rimming steels were made. The analyses of these heats ran 0.07% C. 0.36% Mn. and 0 to 0.105% V. It was noted that the besseraer ingot (containing 0.05% V), and the two higher vanadium openhearth ingots (0.09) and 0.105% V) did not rim satisfactorily. The ingots were hot rolled, coiled at 1470° F., pickled, cold reduced to 20-SWG, sheared, and bright annealed at 1256° F. for 20 hr. Tensile specimens were prepared from the sheets and tested for resistance to strain aging. From these tests it was concluded that in a typical openhearth rimming steel the minimum amount of vanadium required to eliminate strain aging is 0,03%. This amount does not affect the rimming seriously. The vanadium addition did not appear to increase the

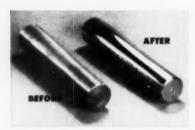
(Continued on p. 190)

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Effects of Alloying on Strain Aging of Rimming Steels

(Continued from p. 188) resistance to strain aging in the bessemer steel.

A series of laboratory heats of chromium-bearing rimming steel was prepared in the same manner as the vanadium-bearing heats. The resistance to strain aging was measured from tensile specimens prepared from these heats. It was found that chromium additions up to 0.45% were not completely effective in climinating strain aging at 212° F. Additions up to 0.2% did not greatly affect rimming action.

The strain aging behavior of the vanadium steels can be qualitatively correlated with the equilibrium between nitrogen, vanadium, and vanadium nitride in the steel. Those steels to which sufficient vanadium had theoretically been added to combine with all of the nitrogen did not strain age, while those theoretically containing free nitrogen were susceptible to strain aging. In addition, it was possible to increase the susceptibility to strain aging in the vanadium steels by annealing at a temperature high enough (1292° F.) to dissociate vanadium nitride. Steels (such as bessemer) containing large amounts of nitrogen would require vanadium additions of such large quantity that the rimming action of the steel is likely to be seriously affected.

The dislocation theory is suggested as a possible mechanism for the action of vanadium on strain aging. Vanadium steels exhibit a pronounced yield point, and so the dislocations present must be anchored by "atmospheres" of the same nature as those believed to exist in plain carbon steels. These "atmospheres" contain nitrogen atoms, and the action of vanadium in eliminating strain aging must be due to preventing the nitrogen atoms in solution in the ferrite from diffusing through the lattice after plastic deformation. This is accomplished by the chemical combination of vanadium and nitrogen, and the "atmospheres" in vanadium rimmed steel must be composed essentially of vanadium nitride F. X. KAYSER molecules.



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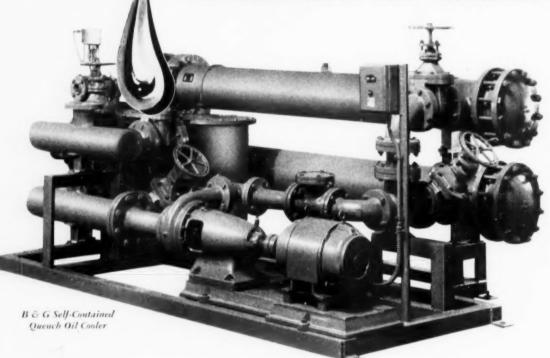
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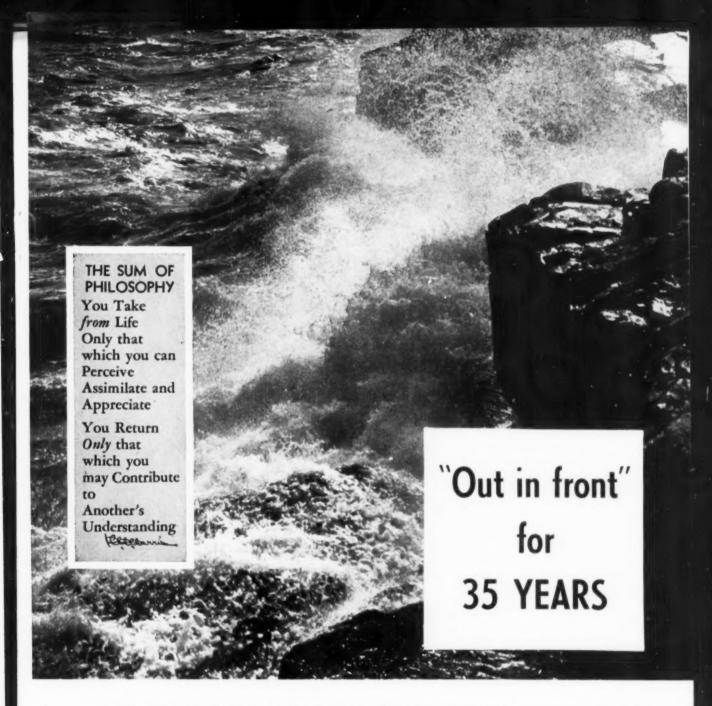


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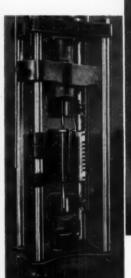
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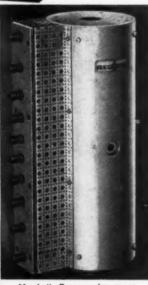
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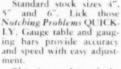
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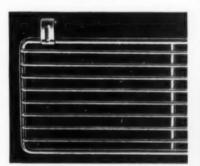
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Here's the "substitute" finish that became standard for so many products because of its quality. First, a plate of 0002" to .0005" of zinc on the product. Then a quick dipping in Unichrome Clear Dip Solution for brilliance and corrosion resistance. Lastly, a Unichrome Clear Enamel which seals in the brilliance despite handling and exposure.

Unusual requirements of four companies met by special Unichrome organic coatings

Finding answers to metal finishing problems can be time-consuming and difficult – especially when metal fabricators attempt the solution unaided. Experience shows that time and money can be saved when a finishing specialist is consulted – particularly if the specialist has had experience with all types of finishes. Here's what happened in four typical cases when United Chromium was called into the picture.



\$15,000 SAVED IN A YEAR

A midwest refrigerator manufacturer coated chromium plated shelves with clear enamel to prevent rusting at the welds. But the coating had poor resistance to wear. Sliding dishes and handling wore off the coating in spots—making the shelves unsightly.

United Chromium, called in on the problem, provided a clear enamel developed especially for chromium to seal out corrosion. With just a single application, this Unichrome "Clear" gave double the former film thickness—also a coating that could take more abuse. Both corrosion and wear were licked. And despite the thicker film, a \$15,000 yearly saving on materials.

STILL "OK" AFTER TWO YEARS

One finisher of dish drainers couldn't find a coating tough enough to withstand severe commercial service. A Unichrome Plastisol was recommend-

A Unichrome Plastisol was recommended. Baskets with this thick, flexible coating are still going strong after 2 years. Never

before had previous coatings stood up so long.

EXCEEDED SPECIFICATIONS 20 TIMES OVER

Specifications for brass refrigerator trim called for a finish to withstand 500 hours of 100% relative humidity at 110 F. The clear enamel being used by this Ohio company failed to stand up, causing a production snag

Consulted on the problem, "The Unichrome Man" was confident it could be solved. Samples were submitted and tested by the company. Results were extraordinary. The corrosion-resisting Unichrome Clear Enamel was adopted after 500 hours. But it then went on to remain in perfect condition for 11,850 hours—that's 493 days!—when attempts to break down the coating were discontinued.



IMMUNE TO PAINT REMOVERS

With doorknobs subject to spattering from housepaints, a lock manufacturer was looking for a clear finish that would remain unbarmed when knobs were cleaned with paint removers. United Chromium solved this unusual requirement with an unusual baking clear synthetic—one with resistance not only to solvents but also to handling, moisture and exposure.

United Chromium has over the years developed a unique line of finishes to satisfy not only the ordinary but also the unusual requirements. To see about a better finish for your products, write, giving details of the problem.

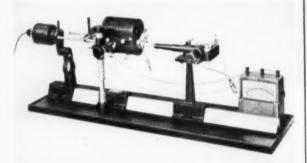
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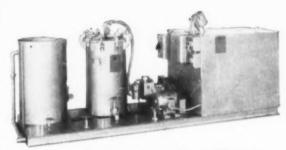
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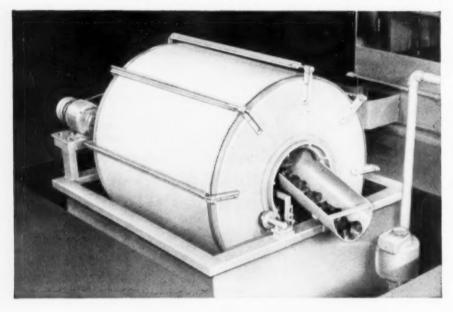


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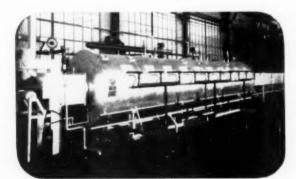
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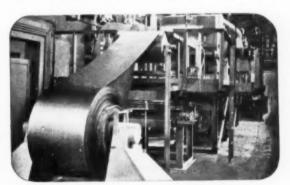
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